Physical Characterization of Connected Buildings Equipment

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Joseph Hagerman (DOE-BTO)
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Chicago, Illinois

Overarching Vision and Objectives

- Vision:
  - For Grid and Building solutions, DOE will provide clear and consistent definition for energy efficient, connected, appliances and equipment (i.e. connected equipment), their characteristics/capabilities, and their potential value to consumers, utilities, and manufacturers.

- Objectives:
  - Work with manufacturers through an open/transparent process to **develop physical characterization protocols**, leveraging existing efficiency testing methods to the extent practical.
  - Work with testing labs to develop the capability to **conduct characterization tests**, leveraging the existing testing infrastructure to the extent practical.
  - Work with market participants and stakeholders to define and **communicate the value of "connected equipment**," leveraging existing DOE and FTC programs.
  - Work with utilities to encourage appropriate **deployment** of energy efficient and connected equipment, leveraging existing utility efficiency programs after the benefits and values are clear.

Meeting Goals

- Goal of this meeting is to discuss…
  - Day 1:
    - "Recap" where DOE is in terms of Characterization
    - Discuss outstanding issues raised in our past characterization meetings
    - Hear from industry about their vision, interest, activities relating to characterization
  - Day 2:
    - Discuss maturity model for connected equipment
    - Develop prioritized list of equipment to be characterized
    - Discuss DOE's interest in a model test rig for connected characterization

- Continue to hear from industry and respond
  - "We all believe connected equipment is increasing in the marketplace, what does DOE need to do/not need to do!"

Ground Rules and Introductions

- Please turn your cell phones down or off
- Share the air
- Stay in the room & take side conversations outside
- Specifically...
  - We are here today to talk about the Framework for Characterization and start discussing how to proceed with characterization
  - This is not a regulatory activity. It is voluntary.
  - We will provide summary notes, but are not recording this session nor providing a meeting transcript.

Per the Federal Register Notice, "Grid connected water heaters are subject to an ongoing rulemaking proceeding and will not be discussed at the meeting."

Characterization of Connected Equipment:

An Introduction & Where are we going?

Thoughts after 2 public meetings &
Docket EERE-2014-BT-NOA-0016 (closed)

Joe Hagerman

Senior Advisor, DOE-BTO

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DOE-EERE…

The Office of Energy Efficiency and Renewable Energy's mission is to:

- **Enhance energy efficiency** and productivity;
- **Bring clean, reliable and affordable energy technologies** to the marketplace; and
- **Make a difference in the everyday lives** of Americans by enhancing their energy choices and their quality of life.

EERE spent $16.8 billion in ARRA funds to stimulate jobs and help create a clean-energy economy in the US.

Office of Energy Efficiency and Renewable Energy

Program Priorities	
Biomass	Investing over $1.4 billion to achieve cost competitiveness and commercialization of cellulosic and other advanced biomass feedstocks and biofuels through applied research, next generation pilot scale development, commercial scale biorefinery demonstrations and targeted infrastructure activities.
Buildings	Implementing a systems approach in deploying technologies for "net-zero" energy buildings that produce as much energy as they consume. Builder's Challenge, the Commercial Buildings Initiative, and accelerated building codes and appliance standards implement this new approach.
FEMP	Doubled energy efficiency investment in Federal building through $1 billion of private-party performance contracting. New ESPC contracts will support up $80 billion in energy savings at federal facilities and increase individual contract ceilings to $5 billion over the life of the contract.
Geothermal	Program renaissance emerged on foundation of Enhanced Geothermal Systems (EGS) that allows geothermal energy to be harnessed nationwide providing up to 10% of our Nation's future electricity.
Fuel Cells	Added focus on near-term stationary and early market applications to create economies of scale, accelerate learning-by-doing, and reduce cost of technology for transportation market.
Industrial	Concentrating on the Save Energy Now program, which through energy assessments has resulted in savings of over $100 million and 75 trillion Btus of natural gas.
Solar	Achieve grid parity with PV and other solar technologies by 2015 through advanced R&D over the entire supply chain. Re-invigorate Concentrated Solar Power program through launch of energy storage research and demonstration.
Vehicles	Focusing on fuel flexible Plug-in Hybrid Electric Vehicles through greatly enhanced battery research activities and new utility partnerships.
Weatherization/SEP	Developed stronger ties with States and utilities by providing technical assistance and by developing "best practices" and model policies for faster and larger scale adoption of efficiency and renewable energy.
Wind & Water Power	Assessed feasibility for wind energy to provide 20% of our Nation's electricity which led to new industry vision. Launched new program in wave, tidal and current energy.

Building Technologies Office
Delivering Energy-Efficient Solutions

Emerging Technologies

High-impact building technologies

~Five years to market-ready

Residential Building Integration

Cost-effective technologies, tools, solutions

Peak energy performance in new & existing homes

Commercial Building Integration

Cost-effective technologies, tools, solutions

Peak energy performance in new & existing commercial buildings

Codes & Standards

Building energy code language with adoption/compliance strategy

National appliance & equipment standards

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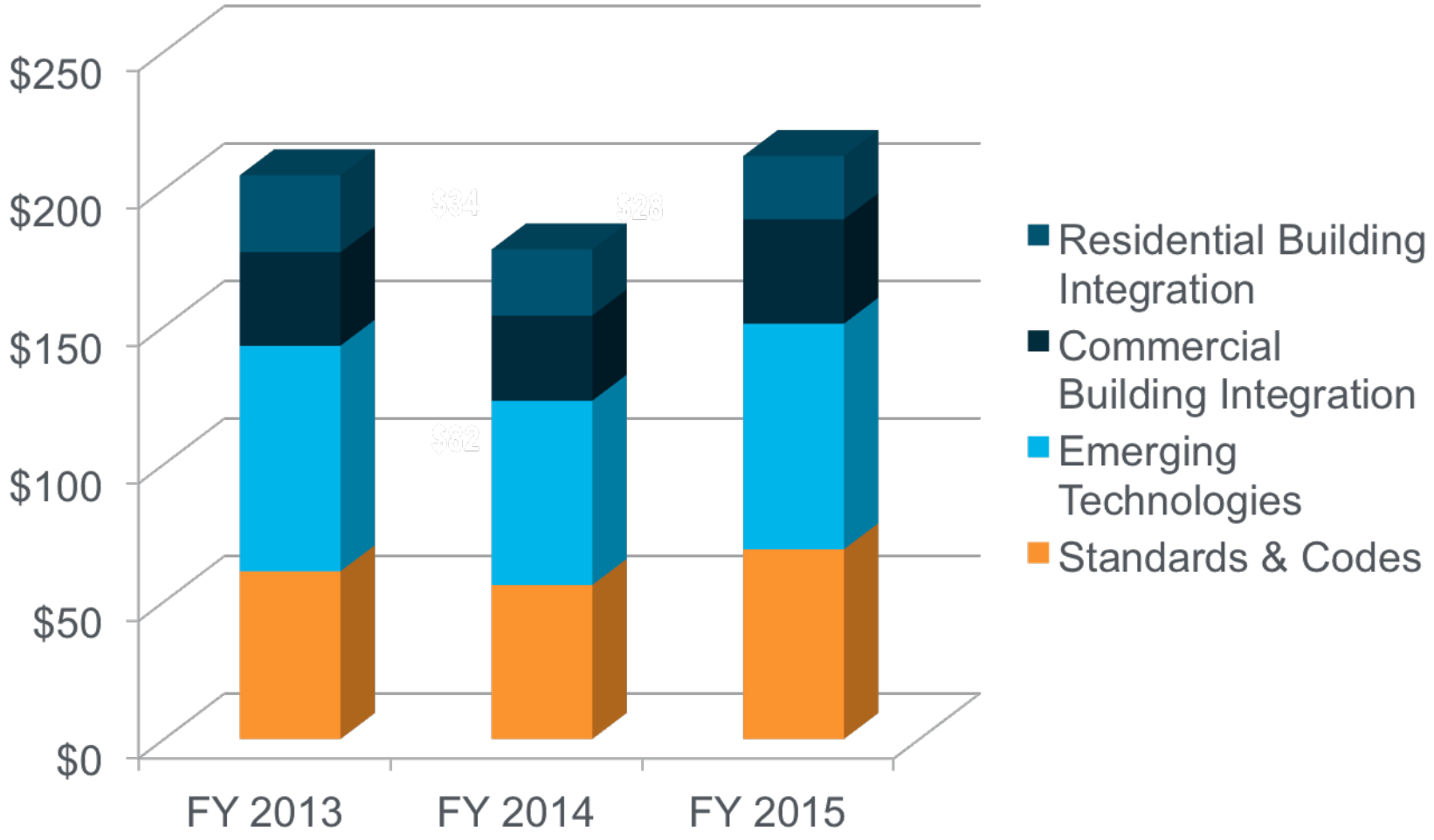
BTO Funding by Program



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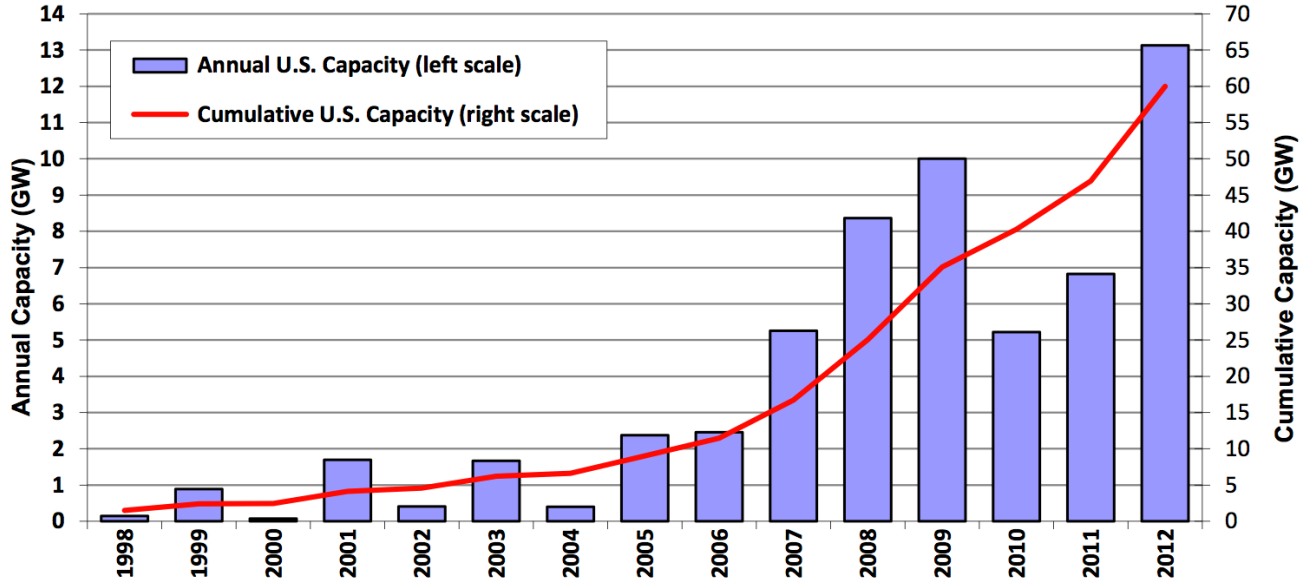
Grid Integration Initiative

- As EERE **drives down the cost** of emerging technologies, these technologies have started to proliferate into the energy system.
- The Grid Integration Initiative **addresses challenges** associated with the physical operation of the power system when these technologies are deployed at scale.



Source: AWEA project database

Figure 1. Annual and Cumulative Growth in U.S. Wind Power Capacity

Seamlessly integrating these technologies into the grid in a safe, reliable, and cost-effective manner is critical to enable deployment at scale.

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EERE Grid Integration Activities

- Successful large-scale deployment of EERE's portfolio of clean energy technologies will require the **development of new technologies and techniques** to address grid integration barriers and opportunities associated.

- EERE technologies and solutions includes **improved approaches to technologies and deployments of technologies**. Examples include…

  advanced power electronics (RD), "grid responsive" building technologies (INTEGRATION); vehicle-to-grid technologies (BOTH RD & INTEGRATION), etc…

- **Close engagement and collaboration** with and among industry and other stakeholders are needed to develop and deploy the necessary standardized communication and control protocols to enable these devices and techniques to successfully interface and interact to enable grid operations while maintaining or improving grid reliability.

How are we going to accomplish these goals?

- **Engage** with utilities, municipalities, and cooperatives for community scale solutions;
- **Develop** and advance common platforms, especially data formats and communication protocols, necessary for a modernized and more flexible distribution system; and
- **Leverage** substantial existing installations of photovoltaic systems, electric vehicles, building energy technologies, storage, and smart grid technologies.
- **Encourage** partnerships between industry, vendors, national laboratories, and other stakeholders;

What we believe in…
the Opportunity for Buildings

- **Buildings have a large role** in helping to enhance grid reliability and enabling the rapid integration of Renewable Energy and Storage.

BUT

- **Buildings today are limited** by existing controls systems that can't easily transact at the speed or scale that is required by the grid
  - High cost to "get it right" with existing technology and economics
  - Currently only implemented in large buildings
  - Components are emerging with greater capabilities of control

- **Building solutions must "think across the meter"**
  - Energy Efficiency is at the core, but there are additional value streams to/from third party entrepreneurs
  - Better control of loads have other benefits

- Thinking Differently will unlock new value streams – value streams that rely on performance and service delivery from equipment.

What would success look like in the building domain?

"Across the meter solution to enable transactions for commoditizing energy related services"

- Connected buildings equipment (whether generating or using electricity) should know **how it is performing, how it could perform, and be capable of communicating** that to the internal/external systems and the grid to unlock financial motivation for all participants.
  - Add in technology with "smarts"/intelligence to protect owner/operator from negative consequences
  - Must "know" actual and potential operational characteristics
  - Must be able to match or settle transactions and "report back" to all parties
- These requirements DRIVE the need to "measure" physical response of connected equipment through a structured means.

What is an Energy Efficient and Connected Piece of Equipment?

Energy efficient and connected equipment will have the following characteristics:

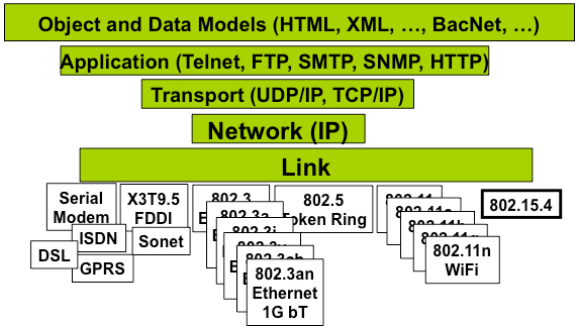
- Can **communicate** with the grid or a building energy management system
  - via AMI, HAN, HEMS/BEMS, smart phone, etc.
  - Some instances will have bi-directional communication capability
- **Standard, open protocol for communicating data/signals** to and from the grid and/or the building energy management system
  - Example data includes equipment status (on/off), total current power, delta power, electricity price, curtail/increase request, duration of request, etc.
- **Sensing and control capability** to decrease or increase load in reaction to that data
  - Some instances will provide necessary feedback on potential and actual response
- Provision for **simple implementation of consumer's desired degree of flexibility** in use of their appliances and equipment with respect to participating or acting upon system signals
- Responses to data/signals **do not negatively impact device life-time**.

DOE has the obligation to the public to define "Connected Equipment" to protect energy efficiency and consumer benefits.

Scale is achievable with Energy Efficient and Connected Equipment

Energy efficient and connected equipment may have the following characteristics:

- Are energy efficient products (as covered by energy conservation standards).
- Have the capability to communicate with the grid or a building system in an interoperable manner.



- Have a standard, open protocol for communicating data/signals to and from the grid and/or the building system
- Have sensing and control capability to decrease or increase load in reaction to that data

- Allow for provision for simple configuration and implementation of consumer's desired degree of flexibility in use of their equipment with respect to participating or acting upon system signals
- Able to respond to data/signals do not negatively impact device life-time.

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Scale is achievable with Energy Efficient and Connected Equipment

Characterization of EE (BTO, VTO) and RE (PVT, FCT) technologies:

DOE will develop a characterization protocol through a quasi-regulatory process with all relevant national labs.

Development of Data, Communication, and IT "standards" to support open source integration and connection:

DOE will seek agreement on communication, data, and other interoperability "standards" for EE and RE technologies.

DOE will support the development of an open source control OS.

Application of cyber-physical systems to deliver services – through modeled, physical, and hybrid evaluations:

DOE will identify use cases of services that single locations, portfolios and fleets, distribution scale and regional scale require.

DOE will develop and demonstrate how connected physical systems can be applied to deliver grid services.

Development of a financial settlement methods that measure and verify the services delivered by connected EE and RE technologies:

DOE will identify use cases and develop and test formats, structures, and process.es

DOE will develop and demonstrate a simple low cost, generic solution for financial settlement.

Exercise connected equipment through the development of "applications" to increase and enhance the hosting capacity of EE & RE technologies at scale.

Model Test "Rigs"

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What is Characterization?

- **"Characterization"** is the measurement or evaluation of the physical or informational responses that connected equipment can provide.
  - See Backup slides for full definitions of all terms that DOE asked for public comment.

- Examples of characterization:

Physical	- Electrical	Voltage, current, power, phase angle
	- Temporal	Response duration, recovery time, lock out time
Informational	- Experimental	Temperature, pressure, humidity, flow rate
	- Digital	Operating mode, status, forecast, diagnostic

- **Characterization is a voluntary process. It is *not* annual efficiency testing, a labeling or rating program (such as Energy Star), or test procedure development.**

Why is Characterization Important? (1)

- Objectively characterizing engagement of connected equipment will enable integration of intermittent renewable resources at scale and enhance grid reliability/resiliency **while** unlocking potential new value streams for homeowners and building owners and operators.

- Example benefits of characterization include:
  - Help establish a scalable market for connected equipment to deliver grid services.
  - Inform population analyses of scaled effects for utilities to rely on this equipment to deliver services.
  - Protect consumer value (e.g. amenity, quality of service)
  - Protect manufacturers (e.g. violation of warranty)
  - Promote innovation by developing level playing field for evaluating what services can be delivered

Why is Characterization Important? (2)

- Communicate the needs of connected equipment to manufacturers so that they are aware of functions that necessary to provide valuable services to all stakeholders

- Inform stakeholders of the equipment or products classified as connected and the functions they have that may provide value to them

- Assess potential value of services equipment can provide

Expected outcomes of characterization include:

  - Increased confidence in ability of connected equipment to provide valuable services to all stakeholders
  - Define a scalable market for connected equipment

Process to Date (1)

- **4/30/14 - public meeting at NREL, announced in the Federal Register, to engage industry in BTO vision for connected equipment delivering valuable services.**
  - "Physical Characterization of Smart and Grid-Connected Commercial and Residential Buildings End-Use Equipment and Appliances," FR Vol. 70, No. 76, 19322
  - General support for DOE as convener of industry and stakeholders to develop characterization protocols through an open, transparent, voluntary, consensus process.

- **7/1/14 - public meeting in Washington, DC, announced in the Federal Register, to present draft characterization framework to industry and invite comments.**
  - "Physical Characterization of Grid-Connected Commercial and Residential Buildings End-Use Equipment and Appliances," FR Vol. 78, No. 108, 32542.
  - Industry continues to support DOE direction to develop characterization protocols for connected equipment. Emphasis on open, transparent, voluntary, consensus process.

- **8/14/14 – "A Framework for Characterizing Connected Equipment" published in FR Vol. 79, No. 157, 47633.**
  - 23 public comments received either on the process or the framework document itself
  - Revision in progress to incorporate public comments. Final publication scheduled for Dec. 15th, 2014

Process to Date (2)

- **12/2014 – DOE Asked to form an ASRAC Working Group (WG) as a vehicle for engaging industry in an open, voluntary, consensus process to develop characterization protocols.**
  - Process can convene industry to move in unified direction.
  - Overwhelming supported by industry and industry encouraged DOE to employ a consensus process to discuss and develop this area of concentration since it is emerging.
  - ASRAC WG Charter will be to discuss and achieve consensus on:
    - Prioritized list of equipment for which DOE should consider developing characterization protocols.
    - Complete characterization protocols for two highest priority equipment types on prioritized list.
    - Position paper on the industries' and utilities' needs for connected equipment which includes a discussion of important sensitivities (see backup slide XX) as identified by industry during the DOE public meeting and comment process.
  - ASRAC decided to wait for new committee members before moving forward.

- **Today – Keep moving on Characterization by resolving "outstanding issues" and continue to engage with industry.**
  - co-located at ASHRAE winter meeting.

Common Themes Heard…

- Industry overwhelmingly supports DOE's vision, objectives, and process for characterizing connected equipment.
  - DOE should continue to reach out and collaborate with others performing related work.
  - DOE should continue to engage stakeholders in an open, transparent, voluntary process.

- Protocols should be developed through a consensus process.
  - Minimize burden on industry that characterization would impart.
  - Eligibility and approved responses should not stifle innovation.

- Interoperability is critical but was understood to be beyond scope.
  - DOE is addressing interoperability through other means/processes

Topics Identified by Stakeholders During the Federal Register Public Comment Process

1. Scope and status of ongoing related work
2. Reference architectures and their importance on bounding characterization
3. Stakeholder viewpoints on the need for eligibility requirements and an approved response list
4. Impact on voluntary utility programs and “owners” of services
5. Distinction between interoperability and characterization; and implications for characterization
6. Identify services for which characterization protocols are applied
7. How to inform stakeholders of services that connected equipment can deliver

EPA - Energy Star Program

- Developed criteria to recognize connected equipment
  - Defined target response requirements for 2 specific grid services
    - Peak load reduction
    - Spinning reserve
  - Require communications to be based on any standards listed in SGIP catalog, NIST Smart Grid Framework, or those adopted from well known standards making organization
  - Connected equipment allowed to consume 5% more energy than normally required
- Developed test methods to verify response requirements
  - Residential refrigerators and freezers, clothes washers, dishwashers, and pool pumps (in progress)

Australia - Department of Industry

- Developed a standards-based strategy to create a market for electrical products with demand response capabilities
- Established terminology, basic architecture, and satisfactory response modes based on DLC and price driven DR arrangements
- Developed voluntary standard AS/NZS 4755
- Prioritized equipment based on current challenges with the Australian power grid
  - Covers residential air conditioners, water heaters, pool pumps, and EVs
- Verified consumer satisfaction with requirements defined through field testing

California Energy Commission - Title 24

- Energy efficiency (EE) standards for residential and non residential buildings
  - Ensure building construction, system design and installation achieve energy efficiency standard and preserve outdoor and indoor environmental quality
- 2013 EE standards
  - Focus on areas to improve EE of newly constructed buildings, alterations, and additions to existing buildings
  - Include requirements for space conditioning and lighting
    - Controls that allow demand reductions in response to DR signals
    - Economizer fault detection and diagnostics (FDD)
    - Tests to verify FDD functionality are left to the manufacturers to develop

SCE – Residential Appliance DR Testing

- Investigate how manufacturers implement DR capabilities
- Conduct laboratory testing to understand DR capabilities and quantify potential load reduction of appliances during different stages of operation
- Inform utility decision makers, industry engineers, regulatory agencies, or other interested parties
- Have tested clothes washers, dish washers, and refrigerators with DR capability from LG & GE
- Testing based on minimum performance requirements specified for Energy Star

… and the SGIP?

- **The SGIP's stated vision is to further Smart Grid "Interoperability" by:**
  - Facilitating and harmonizing standards development
  - Conducting outreach to establish interoperability
  - Developing reference architectures and implementation guidelines
  - Identifying testing , certification, and security requirements [in the cyber realm]

- **The SGIP's focus on interoperability standards, reference architectures, and communications is beyond the scope of connected equipment characterization.**
  - Characterization of connected equipment measures or evaluates the physical and informational responses that connected equipment can provide.
  - Characterization does not include interoperability or communications.

- **Activities within the B2G and H2G SGIP domain expert working groups are not aimed at characterizing physical responses of connected equipment.**

DOE – Characterization of Connected Equipment Scope

How characterization of connected equipment is complementary to related work…

- The goal is to identify and characterize additional capabilities needed for connected equipment to provide valuable services to all stakeholders (not just grid-related services)
- Consider consumer satisfaction
- Consider protection from misuse of connected equipment

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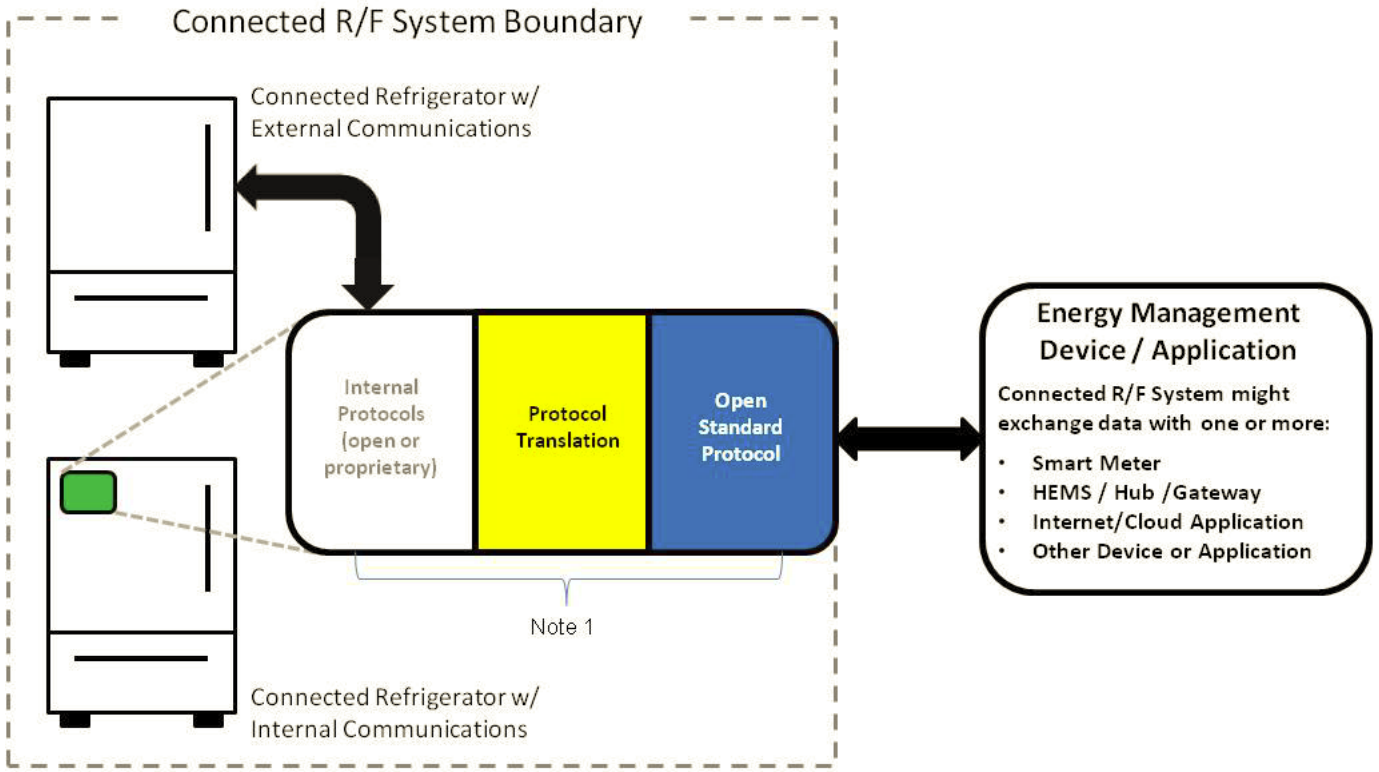
Bounding Characterization

To characterize connected equipment, it is important to understand:

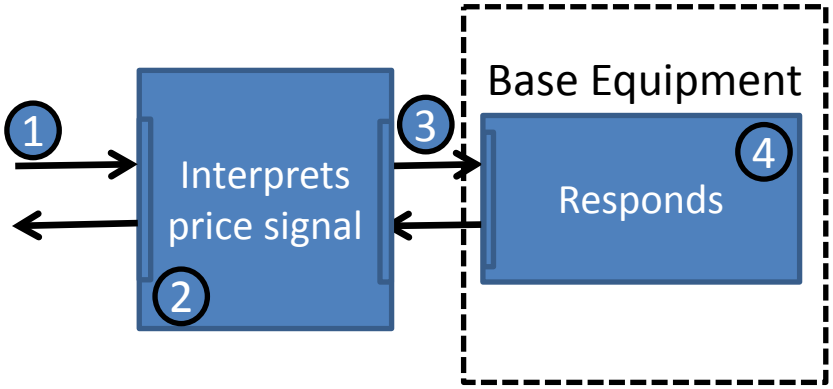
- What functionality we expect connected equipment to have
- Which connected equipment functionalities or capabilities should be characterized
- Which functions can be left to the manufacturers' discretion to verify performance

Bounding Example 1

Connected equipment has the capability to receive, interpret and respond to external signals.



Bounding Example 2



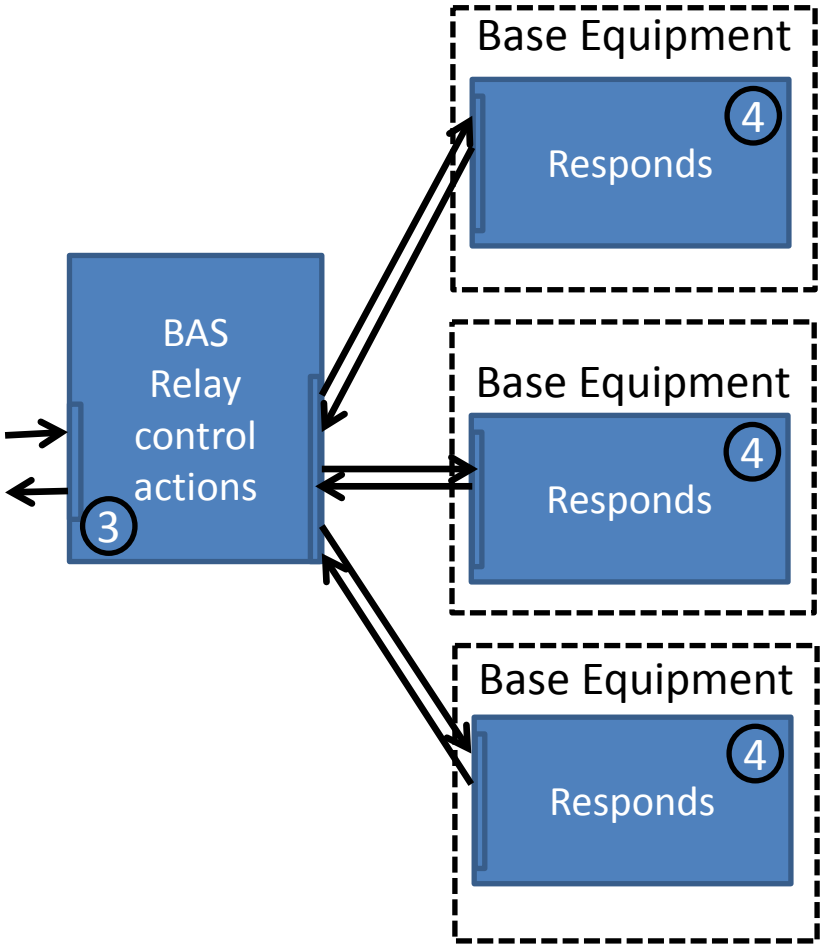
Questions

1. Is the Base equipment considered connected?
2. Is it necessary to characterize both components separately or together (assuming components are sold separately)?
3. What characterization information should be reported regarding individual components?

Bounding Example 3

Questions

1. What is considered to be the connected equipment?
2. Which components should be characterized?
3. What physical and informational capabilities should be characterized in connected equipment?
4. Should there be different categories of connected equipment that should be characterized differently?
5. What should be the scope and boundaries for characterizing connected equipment?



Reference Architecture

- Provides a systematic way to articulate
  - Scope and boundaries of the characterization efforts
  - What is meant by connected equipment
  - What configurations it applies to

- Helps identify important functionalities that should be incorporated in connected equipment

- Helps identify which capabilities should be characterized in a common way, and which ones should rely on manufacturers to verify

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Responses to be Characterized

- Example responses that could be characterized

Response Type	Category	Example
Physical	Load	Adjust load, scheduling/delay
	Consumer	Thresholds, limits
	Equipment	Short cycling, overloading
Informational	Reporting	Alert, history, mode, status
	Applications	M&V, forecasting, diagnostics

Minimum Eligibility Criteria

- Propose that equipment have minimum features in order to qualify for characterization as connected equipment (go/no-go)

- For example, minimum features may include:
  - Two-way digital electronic communication
  - At least one automated response from an approved list of responses

Should there be a step to determine eligibility for characterization?

If so, what are the minimum features?

Approved Response List

- DOE proposes an approved response list to assure stakeholders that equipment responses have value and reflect services

- Developing and maintaining the approved list of responses may reside with a committee responsible for developing characterization protocols

Should there be an approved list of responses to be characterized?

Public Comments

- Comments encouraging an approved response list or minimum eligibility criteria.

"There should be an approved list of responses to be characterized." – *AHRI*

"Two-way communication… should be considered as a minimum feature for eligibility…" – *CA IOUs*

"NEEP proposes the following eligibility requirements for connected equipment…connected equipment: MUST have 2-way communication…" – *NEEP*

"…an ad hoc, case-study-driven approach to defining minimum features may be most useful… a reasonable definition of minimum features should evolve over time as DOE and stakeholder gain experience…" – *NRDC*

Public Comments

- Comments discouraging an approved response list or minimum eligibility criteria.

"In order to encourage innovation… there should be no minimum eligibility criteria for submission of a product to be characterized. The characterization application should include a generic option for "other responses". – *NEEP*

"… it is imperative for DOE to ensure that it avoid creating eligibility requirements that would in any way limit technology innovation or adoption." – *NRECA*

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Impact of Characterization on…

- Utility programs
  - Quantify benefit
  - Develop new service businesses through controls
  - Craft incentive programs
  - Identify new value streams for controlling devices

- Owners
  - Weigh benefits of connected equipment vs. non-connected equipment
  - Increase awareness of new opportunities and value streams
  - Understanding capabilities

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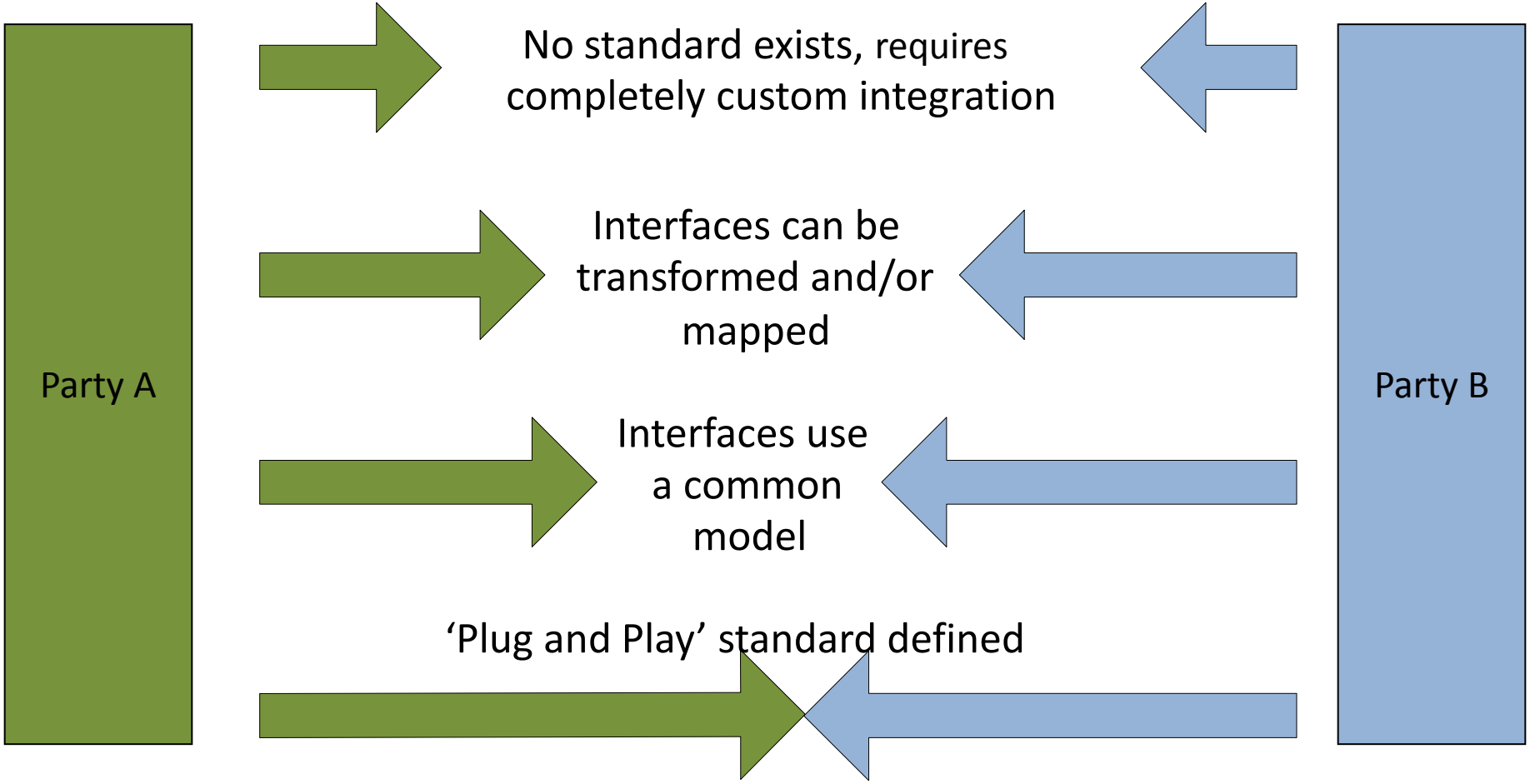
Interoperability Defined

What do we mean by interoperability?

- Exchange of actionable information
  - between two or more systems
  - across component or organizational boundaries
- Shared meaning of the exchanged information
- Agreed expectation, with consequences, for the response to the information exchange
- Requisite quality of service in information exchange
  - reliability, fidelity, security

Reducing Distance to Integrate



Credit: Scott Neumann, UISol GWAC position paper

National Strategy for Interop Whitepaper*

- Task 1: Develop an interoperability vision
  - Invite stakeholders to align on an aspiration for the future
  - Result: vision document through technical meetings engagements
- Task 2: Develop a baseline and framework for stakeholder taxonomy
  - Assemble sources of interoperability information
  - Identify a stakeholder taxonomy and important organizations
  - Result: landscape document and plan for stakeholder engagement
- Task3: Develop a multi-year roadmap
  - Prepare a process to create a roadmap
  - Result: roadmap document through technical meeting engagements

*"The deployment of connected equipment is an untapped national opportunity – for operational efficiency, for new business growth, and to lessen the effects and burdens of climate response."**

* Joe Hagerman, "Towards a National Strategy for the Interoperability of Connected Equipment," 14 Aug 2014

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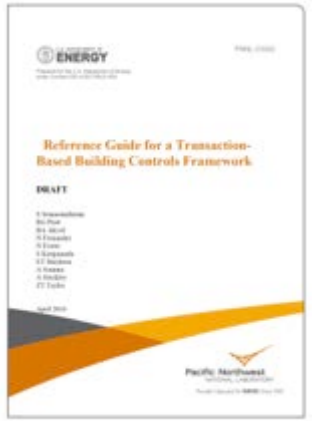
The Reference Guide: A Vision for Services

- **Grid Services**
  - Traditional services the Grid needs -from DR to Ancillary Services
    - How can EERE technologies deliver these services at the lowest cost?
    - McKinsey report quantifies the value of these services but it does not match solutions to EERE technologies
- **End User Services**
  - Operations, Maintenance, and Energy Efficiency of behind the meter assets (example: EE, Continuous Commissioning)
    - EERE technologies have historically focused on these services. How can we best consolidate these value streams?
- **Energy Market Services**
  - New services where energy production and "use" can be exchanged between parties (potentially outside of regulated markets). Example: Provision of energy storage to avoid capacity charges
    - How do we explain and then help the market capture these values? We must identify potential energy market services that can be provided by these technologies.
- **Societal Services**
  - Services that "society" needs or values (example: Staging of recovery)



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Informing Stakeholders of Services

- As potential users of connected equipment; utilities, building owners, operators, and consumers should be aware of service that connected equipment can deliver.

- What information should be communicated?
  - Checklist of responses connected equipment is capable of
  - Metrics from characterization

- How should information be communicated?
  - Periodic reports
  - Online registry
  - Label rating or scoring program
  - Some combination

Informing Stakeholders of Services

- As makers of connected equipment, manufacturers should be aware of the functions and responses that are needed to provide services to users.

- What information should be communicated to manufacturers?
  - Information from characterization of non-connected equipment
  - Guidelines or specifications for response capabilities

- How should information be communicated?

- In general, what should DOE's role be in informing manufacturers and users?

Industry Presentations

DAY 2

Overarching Vision and Objectives
Recap from Day 1

- Vision:
  - For Grid and Building solutions, DOE will provide clear and consistent definition for energy efficient, connected, appliances and equipment (i.e. connected equipment), their characteristics/capabilities, and their potential value to consumers, utilities, and manufacturers.

- Objectives:
  - Work with manufacturers through an open/transparent process to **develop physical characterization protocols**, leveraging existing efficiency testing methods to the extent practical.
  - Work with testing labs to develop the capability to **conduct characterization tests**, leveraging the existing testing infrastructure to the extent practical.
  - Work with market participants and stakeholders to define and **communicate the value of "connected equipment**," leveraging existing DOE, Energy Star, and FTC programs.
  - Work with utilities to encourage appropriate **deployment** of energy efficient and connected equipment, leveraging existing utility efficiency programs after the benefits and values are clear.

Meeting Goals

- Goal of this meeting is to discuss…
  - Day 1:
    - "Recap" where DOE is in terms of Characterization
    - Discuss outstanding issues raised in our past characterization meetings
    - Hear from industry about their vision, interest, activities relating to characterization
  - Day 2:
    - Discuss maturity model for connected equipment
    - Develop prioritized list of equipment to be characterized
    - Discuss DOE's interest in a model test rig for connected characterization

- Continue to hear from industry and respond
  - "We all believe connected equipment is increasing in the marketplace, what does DOE need to do/not need to do!"

Ground Rules and Introductions

- Please turn your cell phones down or off
- Share the air
- Stay in the room & take side conversations outside
- Specifically...
  - We are here today to talk about the Framework for Characterization, not about the specifics of how any equipment may be characterized.
  - This is not a regulatory activity. It is voluntary.
  - We will provide summary notes, but are not recording this session nor providing a meeting transcript.
  -

Per the Federal Register Notice, "Grid connected water heaters are subject to an ongoing rulemaking proceeding and will not be discussed at the meeting."

Discussion of Day 1 Topics

- … to be filled out by J Ramirez after Day 1.

Early Thinking on a Maturity Model for Connected Buildings Equipment

What is a Maturity Model?

- A tool for evaluating the status of a given characteristic and tracking changes in maturity over time
- Characteristics may include processes, capabilities, attitudes, procedures, structures
- Maturity models are useful for:
  - Benchmarking against self, sector, industry
  - Analyzing gaps
  - Prioritizing efforts for improvement
  - Tracking implementation
  - Informing roadmap development

Types of Maturity Models

- **Progressive**
  - Dimension measured expresses increasingly better version of attribute
  - For example: Arithmetic Tools

    pencil and paper → abacus → calculator → computer

- **Process (or Capability)**
  - Dimension measured expresses increasingly better structure or process
  - For example:

    Ad-hoc → managed → quantitatively managed → optimized

- **Hybrid**
  - Overlay of progressive and process models

Essential Elements of Maturity Models

- **Domains**
  - Broad areas of importance (value) over which maturity is tracked
  - For example: Risk management

- **Characteristics**
  - Detailed attributes within a domain for which survey questions
  - For example: Does a database exist for capturing risks? Are the risks regularly evaluated? Are the formal procedures for risk mitigation?

- **Levels**
  - Score given to quantify maturity usually having a number and title
  - For example: 0=Default, 1=Initiating, 2=Improving, 3=Pioneering

Example Maturity Models

- Smart Grid MM (progressive)
  - Developed by utilities for utilities to self-evaluate smart grid maturity

Domains

1. Management, regulatory
2. Organization and structure
3. Grid operations
4. Work and asset management
5. Technology
6. Customer
7. Value chain integration
8. Societal and environment

175 Characteristics

Levels

Maturity level	Name	Description
5	Pioneering	Breaking new ground, industry leading innovation
4	Optimizing	Optimizing smart grid to benefit entire organization; may reach beyond organization; increased automation
3	Integrating	Integrating smart grid deployments across the organization; realizing measurably improved performance
2	Enabling	Investing based on clear strategy; implementing projects to enable smart grid (may be compartmentalized)
1	Initiating	Taking the first steps, exploring options, conducting experiments, and developing a smart grid vision
0	Default	Default level, status quo

- Smart Grid Interoperability MM (process)
- Electricity Subsector Cybersecurity Capability MM (hybrid)

Maturity Model for Connected Equipment

- Objectives
  - Maturity of connected equipment to deliver services
  - National level assessment to track progress over time
  - Tool for industry to self-evaluate and compare with others

- Breadth of application
  - Individual equipment
  - Equipment groupings
  - Entire industry
  - National perspective

Maturity Model for Connected Equipment

Domains

Grid
- Capacity
- Energy
- Regulation
- Spinning Reserve
- Peak Load

End-User
- Energy savings
- O&M
- Convenience

Societal
- Carbon Market
- Air Shed Management
- Renewable Portfolio Standards

Characteristics

Ecosystem
- Policy
- Regulations

Market
- Services offered
- Size, penetration

Responses
- Physical
- Informational

Communication
- Open protocol
- Industry acceptance

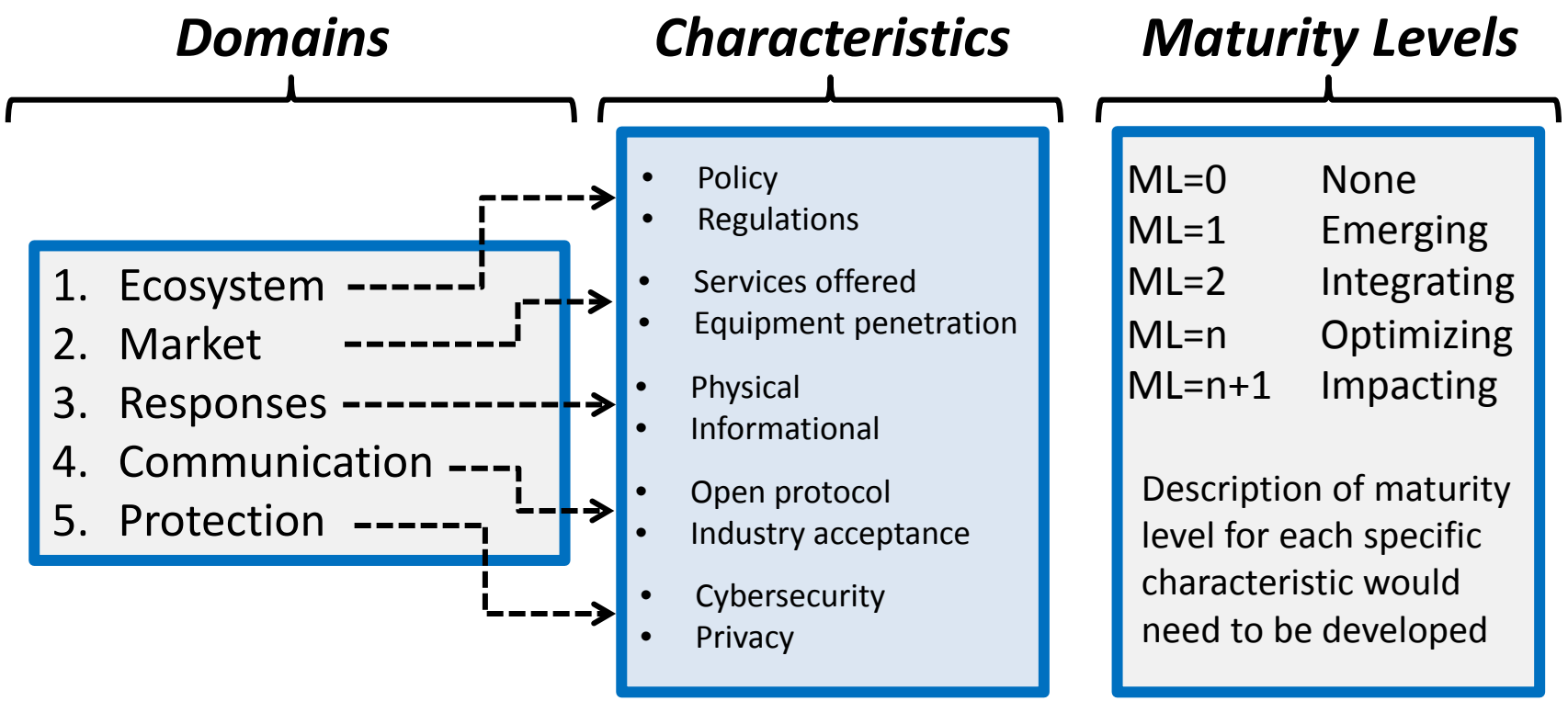
Protection
- Cybersecurity
- Privacy

Maturity Levels

ML=0	None
ML=1	Emerging
ML=2	Integrating
ML=n	Optimizing
ML=n+1	Impacting

Description of maturity level for each specific characteristic would need to be developed

Maturity Model for Connected Equipment



Discussion Topics

- Would a maturity model be useful to industry?
- What domains and characteristics might be considered for evaluating maturity?
- How might a maturity model be used to prioritize connected equipment for characterization?

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

The Prioritization Tool & Data

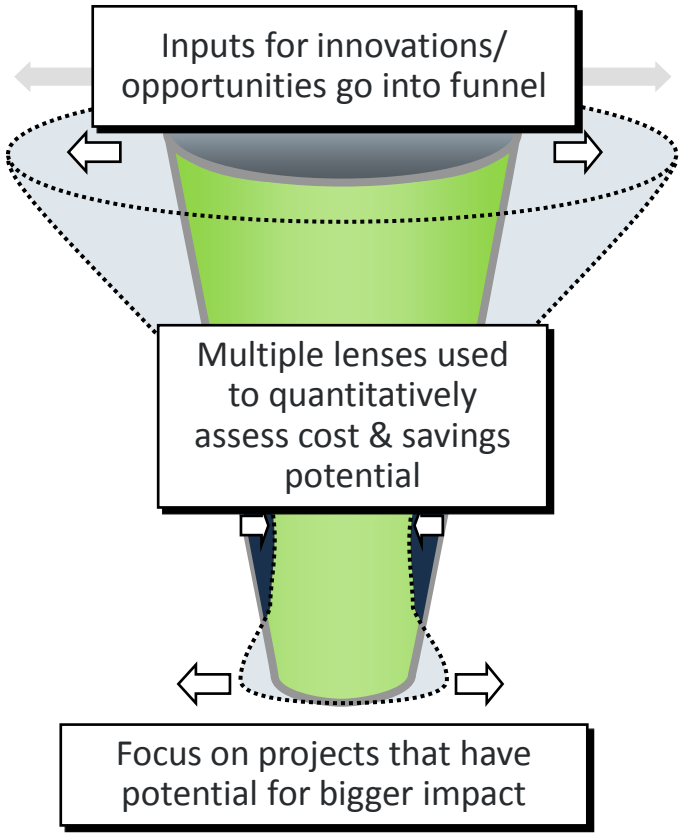
Building Technologies Office
January 2015

BTO's Vision in Developing the Prioritization Tool

Vision: BTO's vision was to develop a comprehensive analytical tool that considers a variety of available building-related energy efficient technologies and activities, and assesses and compares their potential value into the future.

It assesses and compares the performance and cost of 1000+ building efficiency technologies, and estimates potential energy savings across the country under a variety of technology adoption scenarios.

BTO's goal is to use the P-Tool to help maximize impact per unit of government spending.

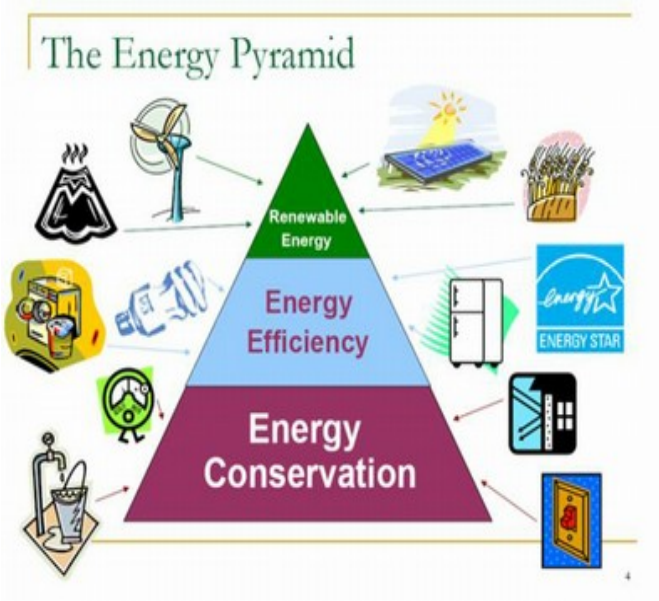


The P-Tool provides insight into decision-making

Purpose: The tool provides quantitative insight and analytical support to influence program and technology planning within BTO.

BTO uses the P-Tool to:

- Generate quantitative goals for programs and sub-programs
- Inform programmatic decision-making
  - Focus on High Impact Technologies (HITs)
  - Identify gaps and opportunities
  - Remove technologies with limited impact
- Set Funding Opportunity Announcement (FOA) topic targets
- Conduct sensitivity analyses ("what if" scenarios) to test realistic target ranges



Other Uses – Federal Energy Management Program (FEMP):

- Recommended top 20 technologies that FEMP should consider in deploying in federal buildings;
- Calculated potential savings that can be achieved if these technologies were deployed;
- Recommended a watch list of high potential technologies currently under development

Results from the P-tool are often examined through one of 4 different "lenses"

LENS 1: Technical Potential

Hypothetically replacing all existing stock with the new measure overnight

LENS 2: Unstaged Maximum Adoption Potential

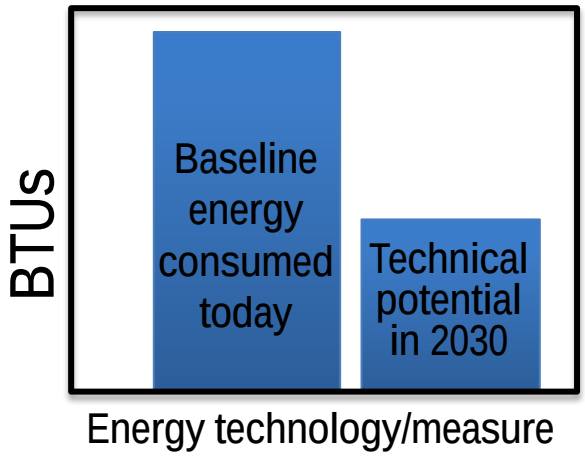
A 'stock and flow' model accounts for unit replacement, elimination or addition

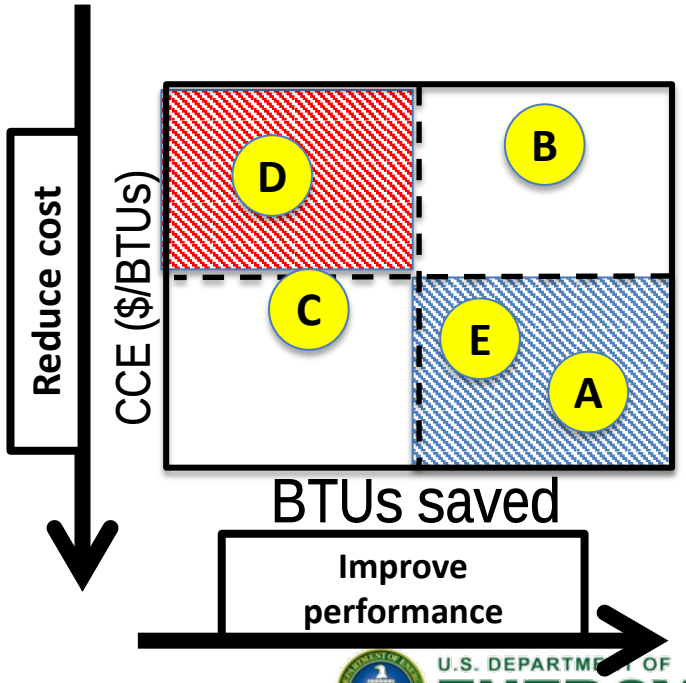
LENS 3: Staged Maximum Adoption Potential

To avoid 'double counting,' measures with lowest CCE "stage" first to capture their share of the market

LENS 4: Adjusted Adoption Potential

Market penetration and BTO influence on acceleration can be examined using the *Bass Diffusion Model* to represent more "realistic" market diffusion

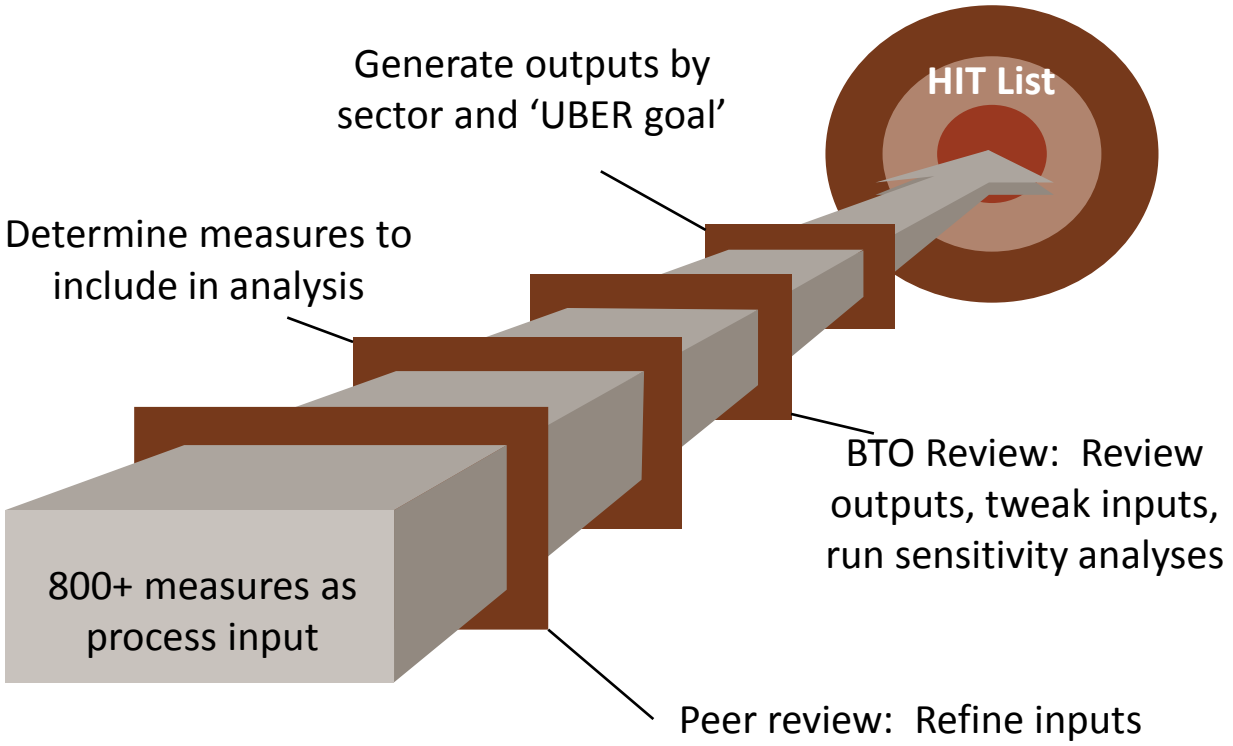




Example #1: The P-Tool can be used to identify high impact technologies

A list of High Impact Technologies (HITs) are developed for the following end-use areas:

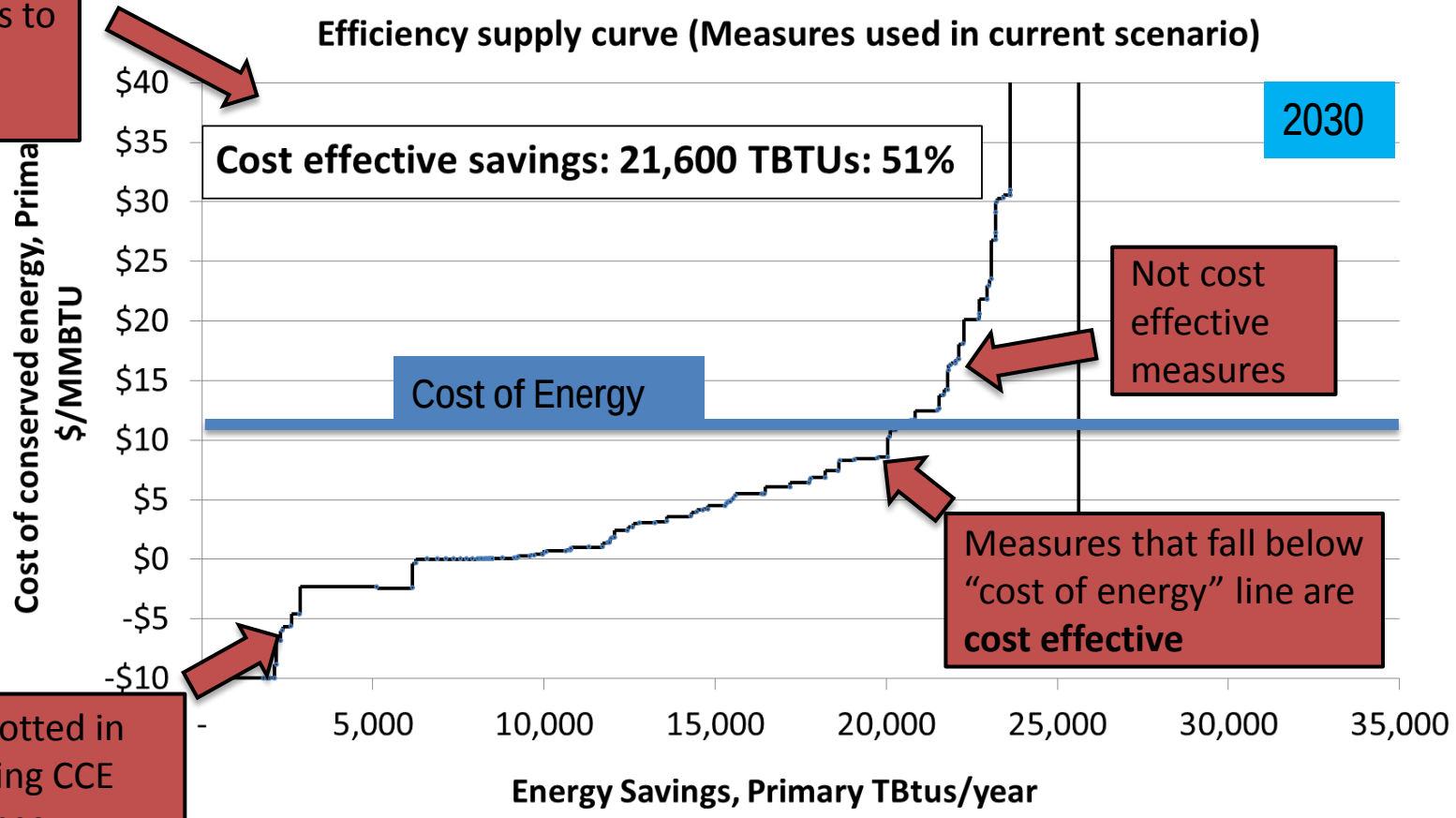
- Windows
- Envelope
- Water Heating
- HVAC
- Appliances
- Miscellaneous Electric Loads (MELs)



Example #2: The tool can be used to assist in establishing of goals

Cost effective measures can be identified among a portfolio of opportunities, and their combined energy savings can be used to assist in formulating goals for BTO.

Compare cost effective savings to baseline to generate goal



Measures are plotted in order of increasing CCE and energy savings

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Who and how can others use the P-Tool?

Federal and Local Governments

- Identify which technologies are cost effective and most applicable to be deployed in their region to most effectively meet their set energy savings targets

Utilities

- Identify technologies to deploy for their region for peak demand management
- Design incentives around technologies that have high energy savings potential, but which are not yet cost attractive for consumers

Technology Companies

- Estimate energy savings for proposed technologies during FOA application process
- Identify biggest markets and areas of opportunities where new energy efficient technologies are needed
- Compare their technologies' cost and performance to other products on the market

The tool presently contains over 1000 measures, with inputs defined based on high quality sources.

Building Envelope

- R: PCM in New Home Attics
- C: Dynamic Windows
- R: Seal Ducts in Existing Homes
- C: R-5 Replacement Windows
- R: R-30 Walls in Existing Homes

Sensors & Controls

- R: Home Automation
- C: Optimized Whole-Building Controls
- C: RTU AFDD
- C: Lighting Occupancy Sensors
- R: Predictive Thermostats

HVAC

- C: Demand Ventilation
- R: Cold Climate HP
- R: Integrated HP
- C: Advanced RTU
- R: SEER 24 CAC

Water Heating

- C: Advanced Heat Pump Water Heater
- R: Tankless Water Heater
- R: Solar WH, Indirect Passive
- C: Condensing Gas WH
- R: WH Insulation Blankets

Lighting

- R: CFLs
- C: LEDs
- C: High Efficiency Ballasts
- R: Low Wattage HID

MELs

- R: Set Top Box Standard
- C/R: Desktop Power Management
- R: Efficient Ceiling Fan Motors
- R: Broadband Device Standard
- C: Fitness Equipment

Refrigeration

- C: Thermionic Refrigeration
- C: Max Tech Walk-In Refrigerators
- R: Retire Old Refrigerators
- C: VIP in Refrigerators
- C: Fiber Optic Lighting in Refrigeration

Appliances

- C: Electric Oven Standard
- R: Induction Cooktops
- R: Improved Microwave Magnetron Efficiency
- R: HP Clothes Dryer
- C: Low Temperature Detergent

Within the commercial building sector, there are many different technologies that consume energy

	Energy Use (TBTU, 2010, site)	Floorspace (billion sq.ft.)
Cooling		
1. Rooftop Unit.....	219	35
2. Chiller (Recip., screw, scroll).....	107	17
3. Centrifugal Chiller.....	62	10
4. Residential Style A/C,.....	54	9
5. Wall/Window A/C.....	52	8
6. Air- & Ground-Source Heat Pump	7	1
Heating		
1. Natural Gas Furnace.....	1,082	41
2. Natural Gas Boiler.....	534	21
3. Distillate Boiler.....	91	5
4. Electric Resistance.....	77	5
5. Electric Boiler.....	56	3
6. Distillate Furnace.....	59	3
7. Air- & Ground-Source Heat Pump	47	3

	Energy Use (TBTU, 2010, site)	Floorspace (billion sq.ft.)
Electronics		
1. Office Equipment - non-PCs.....	227	81
2. Office Equipment - PCs.....	137	81
Water Heating		
1. Natural Gas Water Heaters....	460	58
2. Electric Water Heaters.....	90	17
3. Distillate Water Heaters.....	20	5
Appliances		
1. Refrigeration Equipment.....	392	81
2. Cooking Equipment.....	209	81
3. Dishwashers.....	84	0.4*
Lighting		
1. Linear Fluorescent.....	2,716	1,631*
2. High Intensity Discharge.....	540	35*
3. Reflectors.....	166	76*
4. General Service Lamp.....	141	75*

* Note: Stock is provided in equipment units (millions), rather than commercial floor space.

Within the residential building sector, there are many different technologies that consume energy

	Energy Use (TBTU, 2010, site)	Stock (millions)
Cooling		
1. Central A/C.....	605	62
2. Air- & Ground-Source Heat Pump	118	10
3. Room A/C.....	98	49
Heating		
1. Natural Gas & LPG Furnace.....	2,844	50
2. Natural Gas Boiler.....	500	11
3. Electric Boiler.....	327	29
4. Distillate Boiler.....	249	4
5. Distillate Furnace.....	230	3
6. Furnace Fans & Boiler Circ. Pump	123	69
7. Air- & Ground-Source Heat Pump	62	9
Water Heating		
1. Natural Gas & LPG Water Heater	1,269	62
2. Electric Water Heater.....	425	47
3. Distillate Water Heater.....	64	3

	Energy Use (TBTU, 2010, site)	Stock (millions)
Appliances		
1. Refrigerator.....	378	143
2. Clothes Dryer.....	247	89
3. Stove.....	105	68
4. Dishwasher.....	100	68
5. Freezer.....	79	38
6. Microwave.....	49	111
7. Clothes Washer.....	32	93
Electronics		
1. Television.....	206	290
2. Personal Computer.....	106	259
3. Rechargeable Battery.....	15	1,161
4. Home Audio/Video System.....	8	28
Lighting		
1. General Service Lamp.....	596	3,258
2. Reflector.....	308	753
3. Linear Fluorescent.....	90	443

Prioritization of Connected Equipment to be Characterized

This is a facilitated discussion
and white boarding session.

Hardware to Support Characterization of Connected Equipment

Introduction to Test Rig

- "Test Rigs" are necessary to evaluate the physical & informational responses and communicating characteristics of two common types of appliances and equipment when providing
  - Test Rig 1 will measure physical & informational responses, and
  - Test Rig 2 will measure communication capabilities .

- The "Test Rig" Specification is designed to be generally universal for basic resistive and basic inductive type appliances and equipment.
  - Certain appliances may need some additional measurements.

- DOE's goal is to develop a model "Test Rig" that industry can adopt where that model provides the least burden to the existing market/industry testing capabilities.

Scale is achievable with Energy Efficient and Connected Equipment

Characterization of EE (BTO, VTO) and RE (PVT, FCT) technologies:

DOE will develop a characterization protocol through a quasi-regulatory process with all relevant national labs.

Development of Data, Communication, and IT "standards" to support open source integration and connection:

DOE will seek agreement on communication, data, and other interoperability "standards" for EE and RE technologies.

DOE will support the development of an open source control OS.

Application of cyber-physical systems to deliver services – through modeled, physical, and hybrid evaluations:

DOE will identify use cases of services that single locations, portfolios and fleets, distribution scale and regional scale require.

DOE will develop and demonstrate how connected physical systems can be applied to deliver grid services.

Development of a financial settlement methods that measure and verify the services delivered by connected EE and RE technologies:

DOE will identify use cases and develop and test formats, structures, and process.es

DOE will develop and demonstrate a simple low cost, generic solution for financial settlement.

Exercise connected equipment through the development of "applications" to increase and enhance the hosting capacity of EE & RE technologies at scale.

Model Test "Rigs"

U.S. DEPARTMENT OF ENERGY

Outline

- Big Picture
- Experimental Setup Overview
- Hardware and Terminology
- Scope of the Data Acquisition Platforms
- Data Acquisition Platform specifications
- Illustrative Example: Room air conditioner
- Discussion

Big Picture

- What are we trying to do?
  - Characterize the ability of connected devices to provide ancillary grid services
- What is the scope of this presentation?
  - Describe the hardware functionalities that are necessary for characterizing the functionality of connected devices.
- We need your involvement to guide and improve the process

Overview

- Describe hardware functionalities needed for equipment characterization
- High-level descriptions of each component
  - Additional detail will be developed later in the process, largely driven by your input and advice
- Overall experimental setup similar to existing testing facilities for non-connected equipment
  - Differences mainly in characterizing transient responses and measuring communications

*Characterization**

- The measurement or evaluation of physical or informational responses that are possible for connected equipment.
  - Characterization may include the evaluation of information oriented characteristics (e.g., forecasting, status, or diagnostics).
  - An example of characterization is an accounting of the presence or absence of given features, such as the ability to schedule future events or alert the owner of excessive energy consumption.

* from "A Framework for Characterizing Connected Buildings Equipment" DOE December 2014

Experimental Functionalities

Testing is the sequence of procedures and conditions the equipment will be subjected to for characterization

Coordination links discrete, external functional components to create the characterization conditions and to conduct the testing procedures

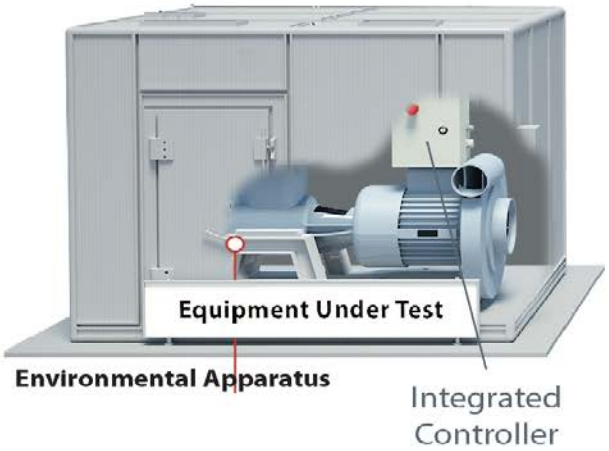
Measurement creates a record of the physical data and communications signals which occur during testing

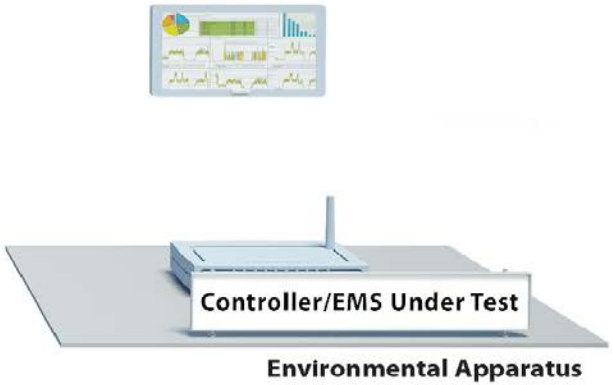
Coordination + Testing + Measurement = Characterization

- **Is this the correct approach?**

Testing

the sequence of procedures and conditions the equipment will be subjected to for characterization

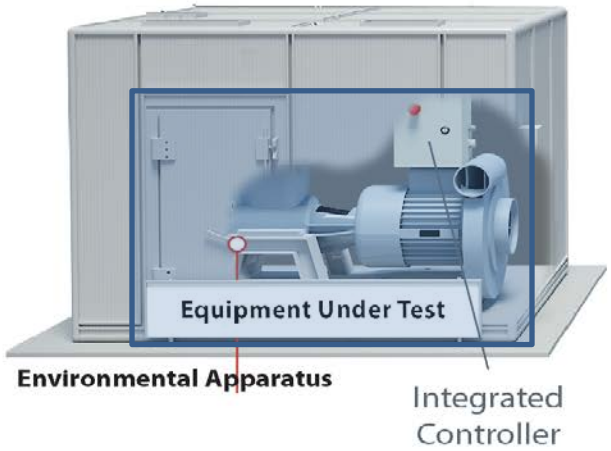


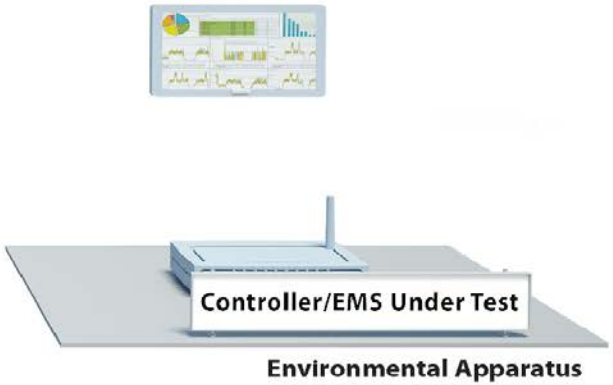


Physical Services Related

Communications Services Related

*Equipment**

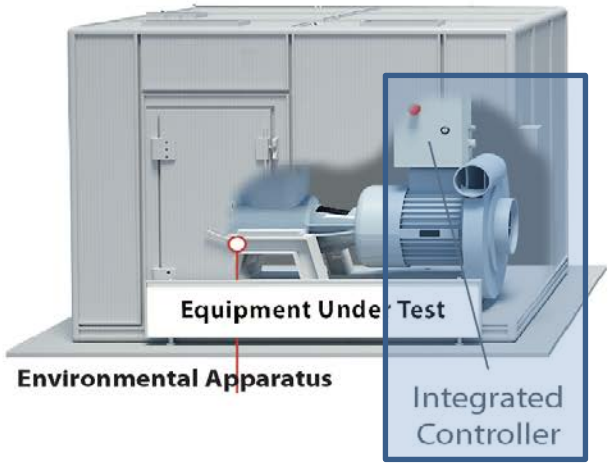


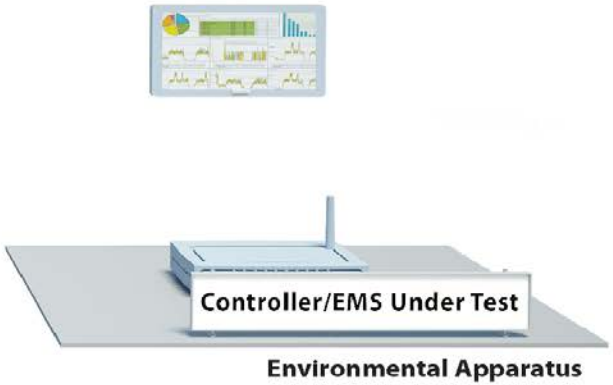


- Building end-use loads that consume, store, or generate electricity while providing necessary services and amenities within buildings.
  - Examples of equipment include: refrigerators, computers, lighting, HVAC, heat pumps, room AC, vehicle chargers, inverters, or energy storage to name a few.
  - Because equipment varies widely in size and complexity, boundaries delineating what is, and is not considered part of a particular piece of equipment should be clearly defined on an individual basis and may occur during the characterization protocol development process.

* from "A Framework for Characterizing Connected Buildings Equipment" DOE December 2014

Integrated Controller



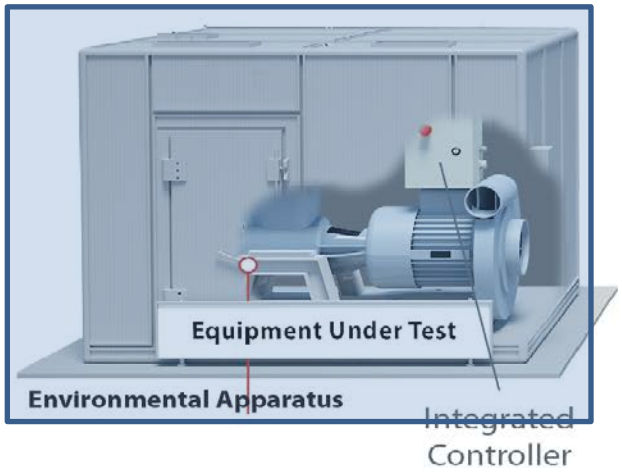


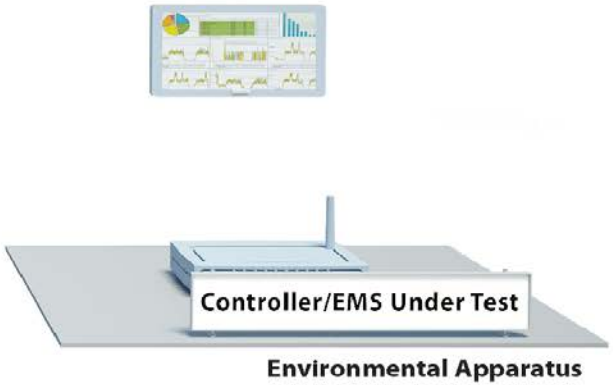
- The hardware and software controller components of the equipment under test that enable it to change its operational parameters based on a variety of inputs, such as information from the grid (third party signal simulator), a controller/EMS, or its inherent internal control scheme.
  - Illustrative Example: A communicating Room Air Conditioner's thermostat is an integrated controller.
  - Illustrative Example: A unitary air conditioner's required, manufacturer-specific thermostat is considered an integrated controller, despite being remotely located.

Controller/Energy Management System Under Test

- The energy management system or controlling device whose communications and/or decisional commands are being characterized.
  - The signal inputs and outputs will be measured using the communications data acquisition platform.
  - Any physical characteristics of interest, such as energy usage, can be measured using physical data acquisition platform.
  - Need for, and any operation requirements for, an environmental apparatus will be determined by relevant characterization procedures

Environmental Apparatus





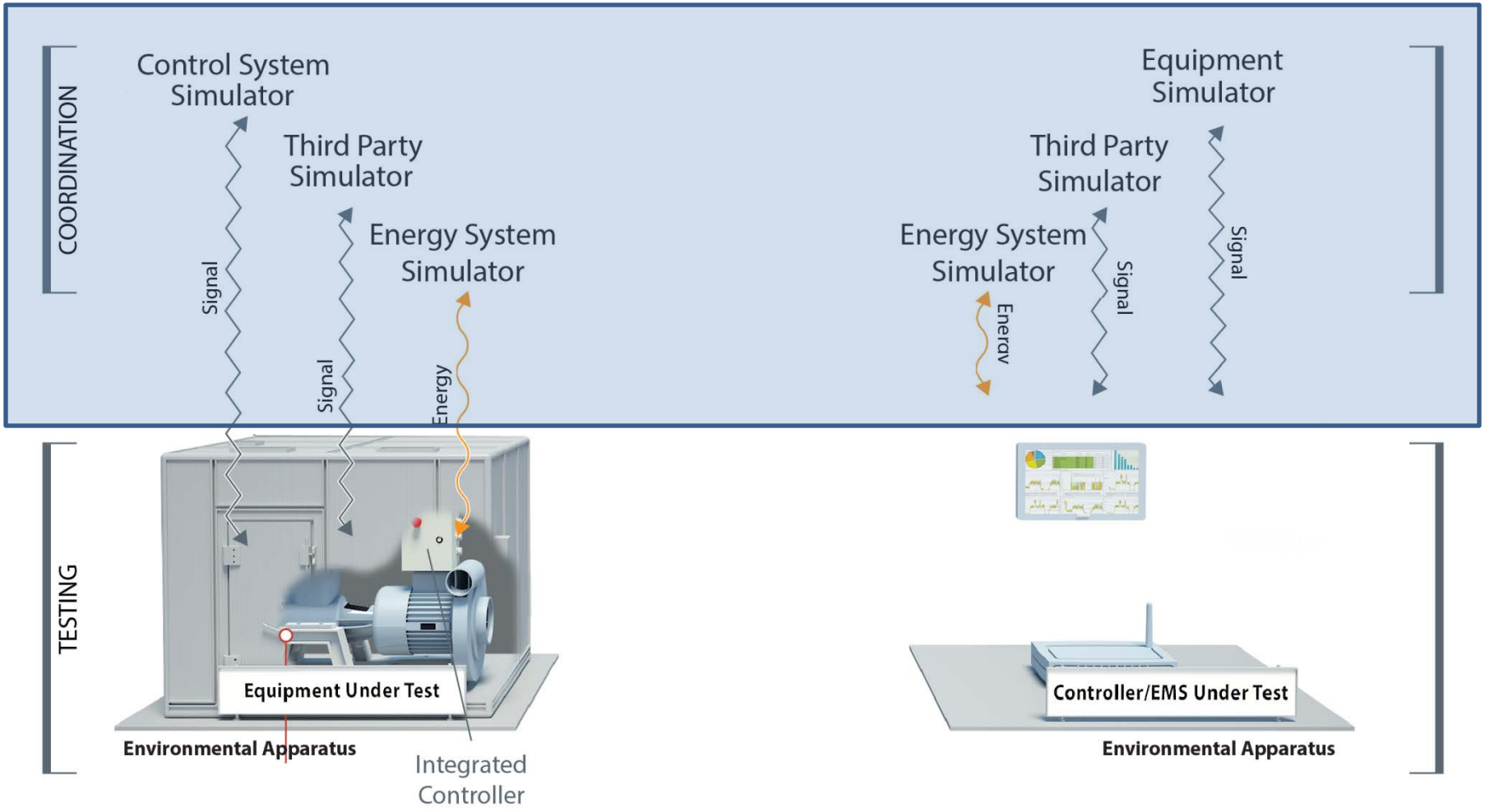
- Produces desired ambient and physical operating conditions, as well as supporting infrastructure, for the equipment under test and/or controller under test (e.g., indoor / outdoor chambers for testing HVAC equipment, plumbing connections for pumps, etcetera).
  - The environmental apparatus for equipment is typically defined in the appropriate section of the Code of Federal Regulations
  - Additional environmental apparatus requirements will derive from characterization procedures

Testing Questions

- Is additional clarification needed to define “testing” in the context of characterization?
- Are there testing components that facilitate characterization that are generally not present in rating laboratory test facilities that should be included here?

Coordination

links discrete, external functional components to create the characterization conditions and to conduct the testing procedures



Coordination

- ***Control System Simulator**:* Apparatus which simulates an energy management system or non-integrated controller when characterizing equipment without these components.
  - Also used when characterization requires a single piece of equipment under test to respond to multiple controllers.

- ***Equipment Simulator**:* Apparatus which simulates one or more pieces of equipment to enable characterization of a controller without these components.
  - Also used when characterization requires a controller or energy management system under test to control several different pieces of equipment.

Coordination

- ***Energy System Simulator****:* Simulates the energy system (e.g. electrical service, gas, water, PV production) for the equipment under test and/or the controller under test by providing energy service and controlling energy service characteristics.

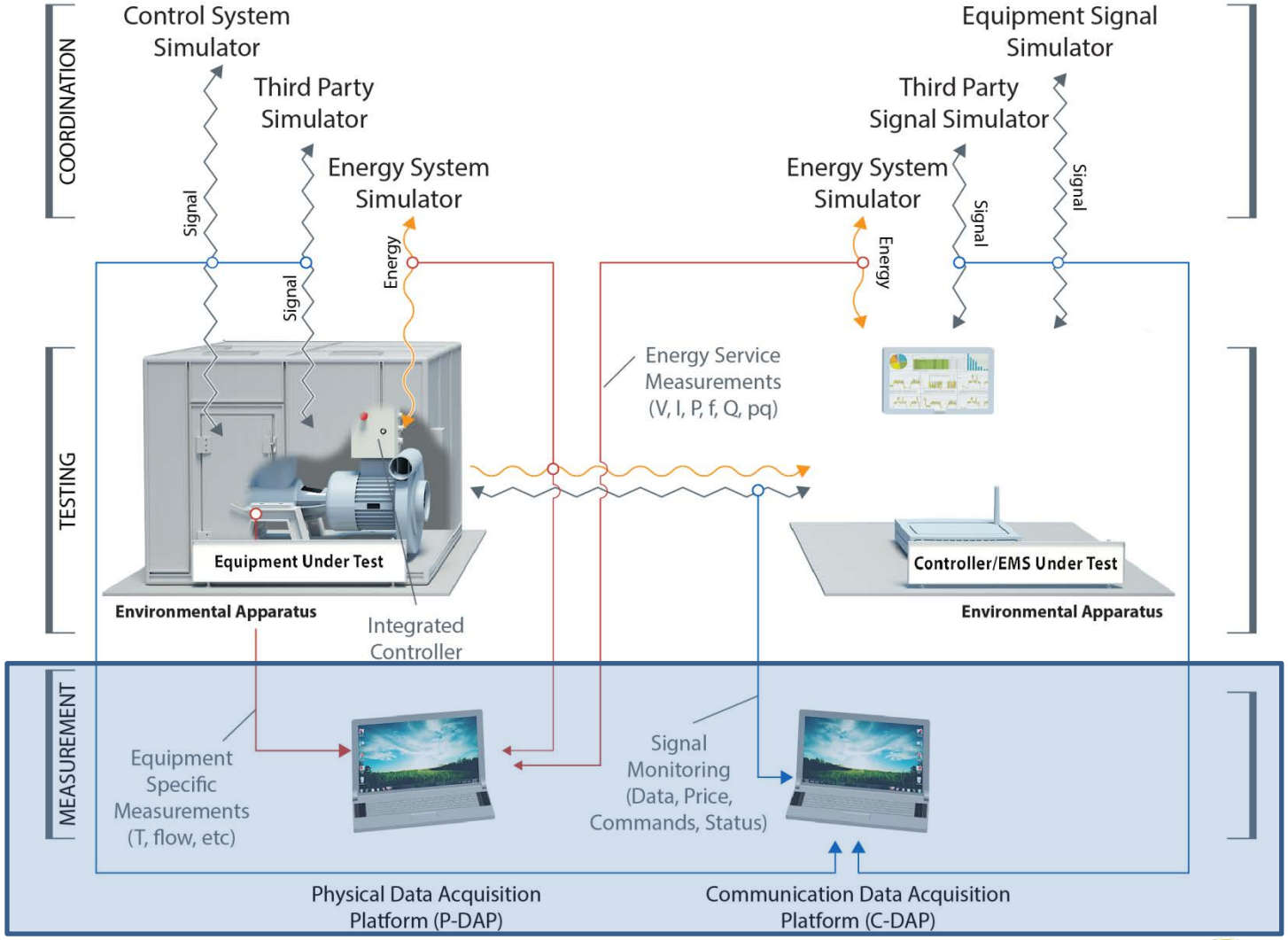
- ***Third-Party Simulator****:* Generates signals that a utility, aggregator, or other third-party would use to request or provide services from/to participating equipment (e.g., load curtailment request, energy prices, equipment status query).

Coordination Questions

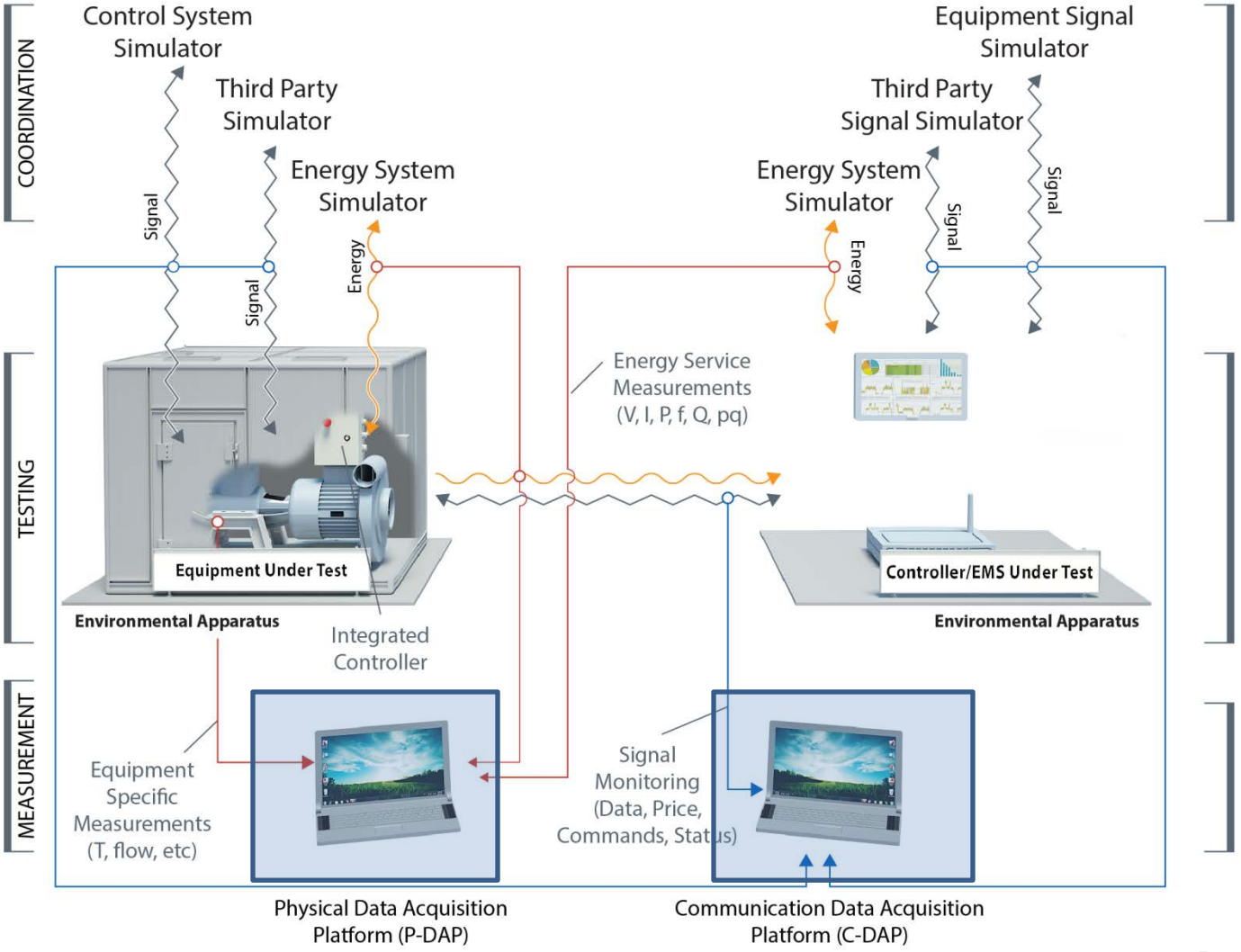
- Are there any additional coordination mechanisms that should be considered?

Measurement

creates a record of the physical data and communications signals which occur during testing



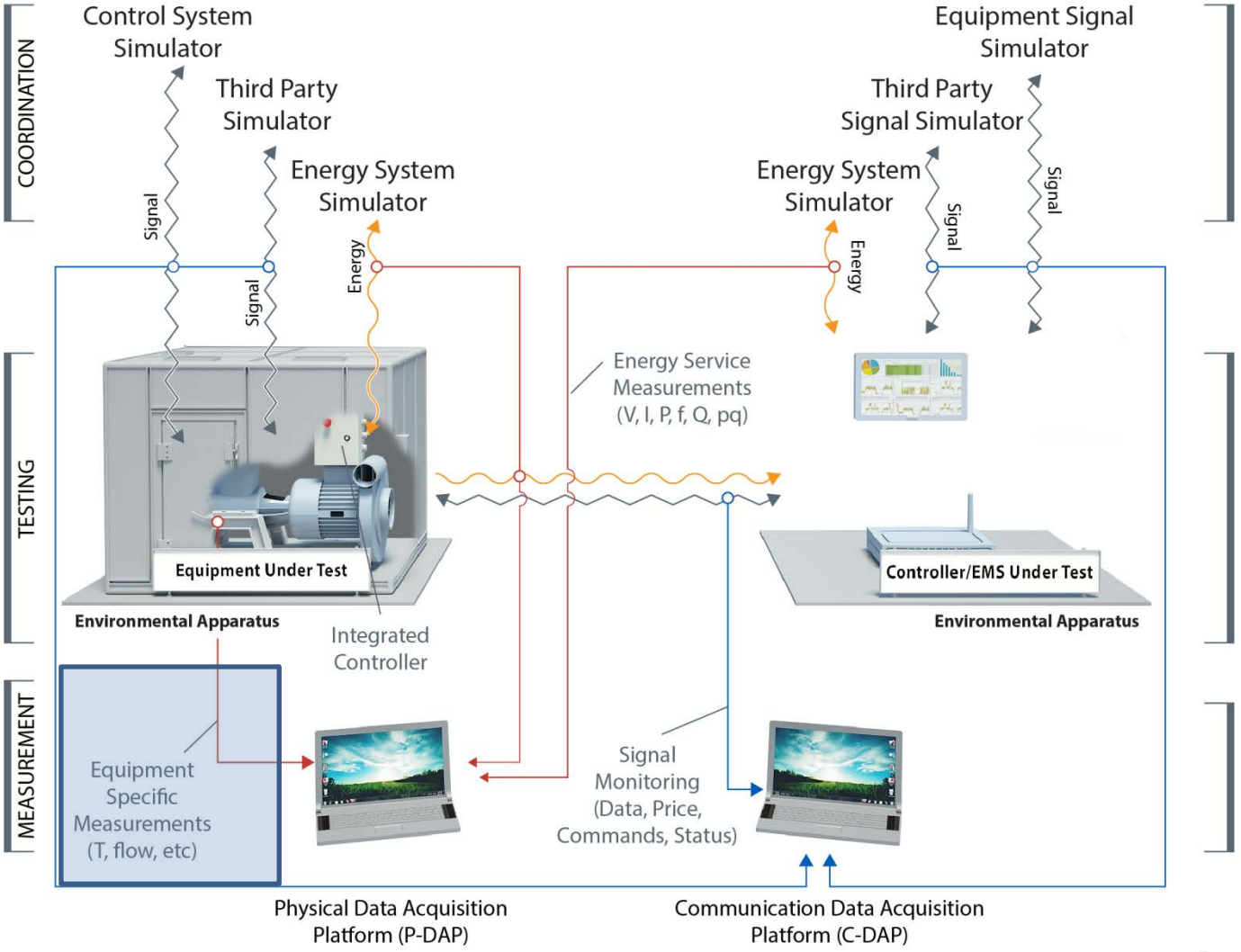
Measurement



Data Acquisition Platform

- Experimental set-up and measurement needs to be used by test facilities to characterize the ability of equipment to provide services (e.g., grid, societal, or building operational services) in addition to their primary functions.
  - ***Communication Data Acquisition Platform*** – The hardware, including instrumentation, and software used to collect communication and information exchange and energy service measurements from controllers/EMS being tested.
  - ***Physical Data Acquisition Platform*** – The hardware, including instrumentation, and software used to collect equipment-specific and energy service measurements.

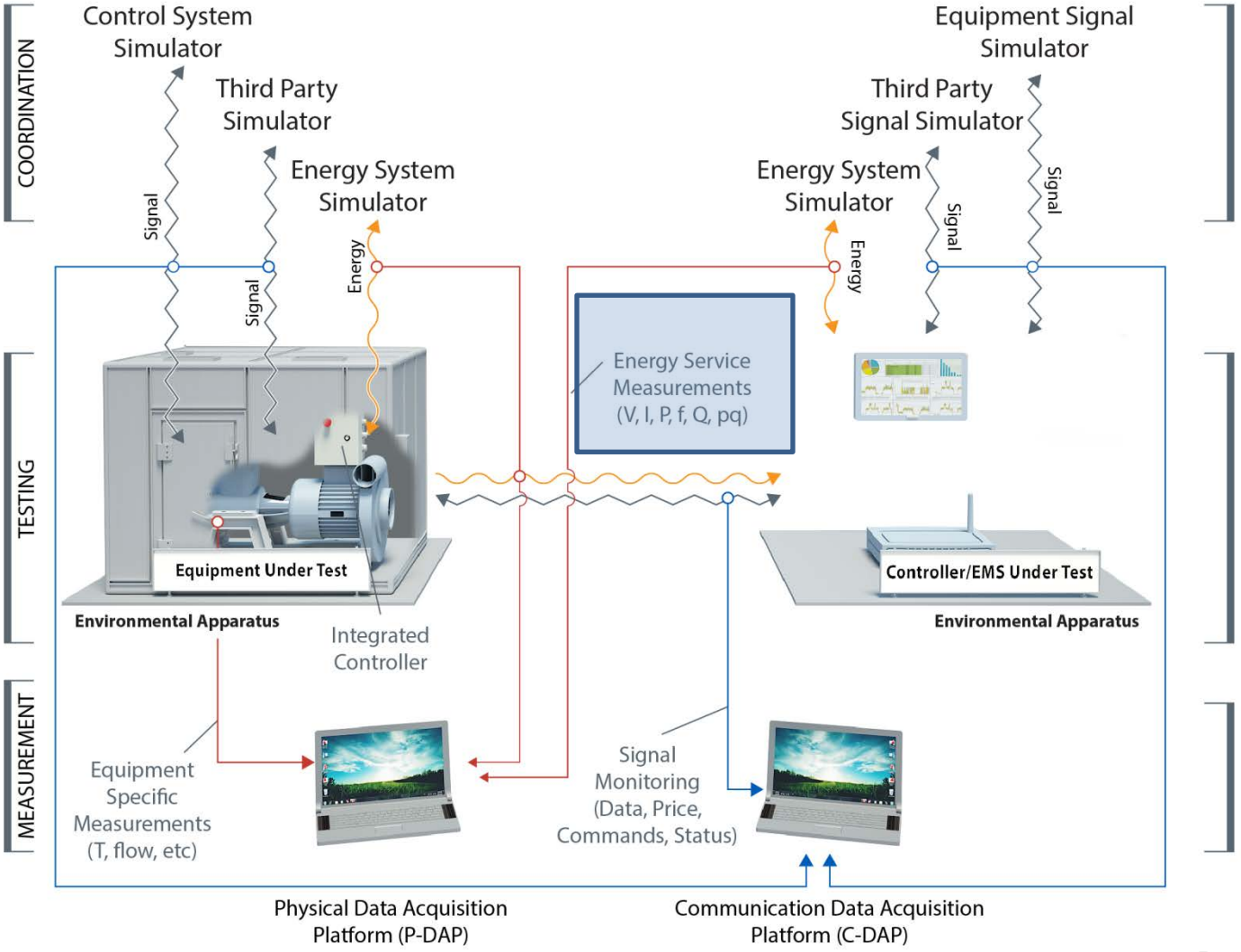
Measurement



Equipment-Specific Measurements

- Measurements of physical quantities (e.g., temperatures, pressures, flow rates, etc.) for the equipment under test that indicate its physical state and help to evaluate how it performs its primary function.

Measurement



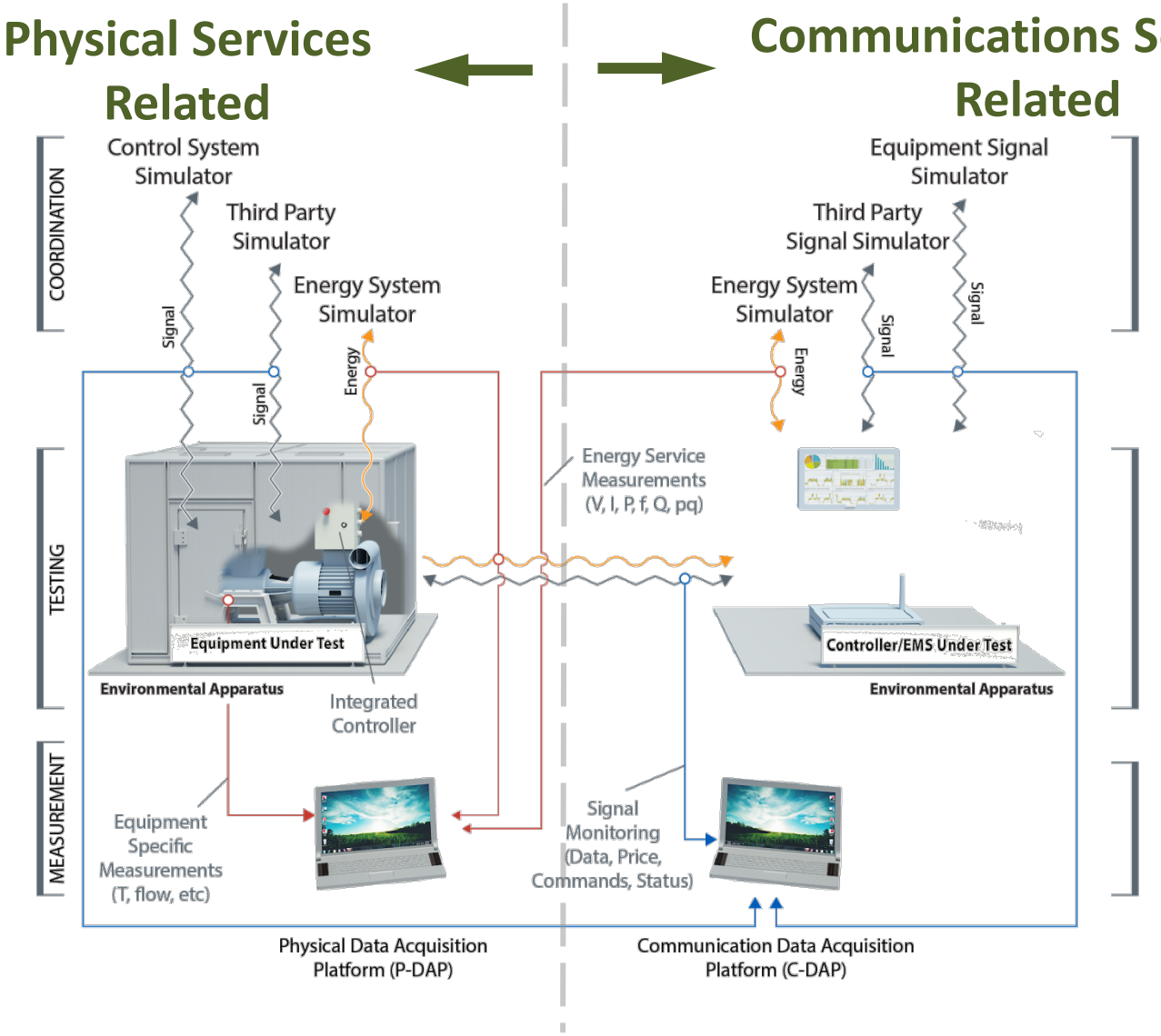
Energy Service Measurements

- Measurements of physical quantities related to the power flow between the grid and the equipment under test. The list will typically include voltage, current, frequency and power quality, but it can be expanded to accommodate specific situations not articulated here, for example when there are alternate energy sources.

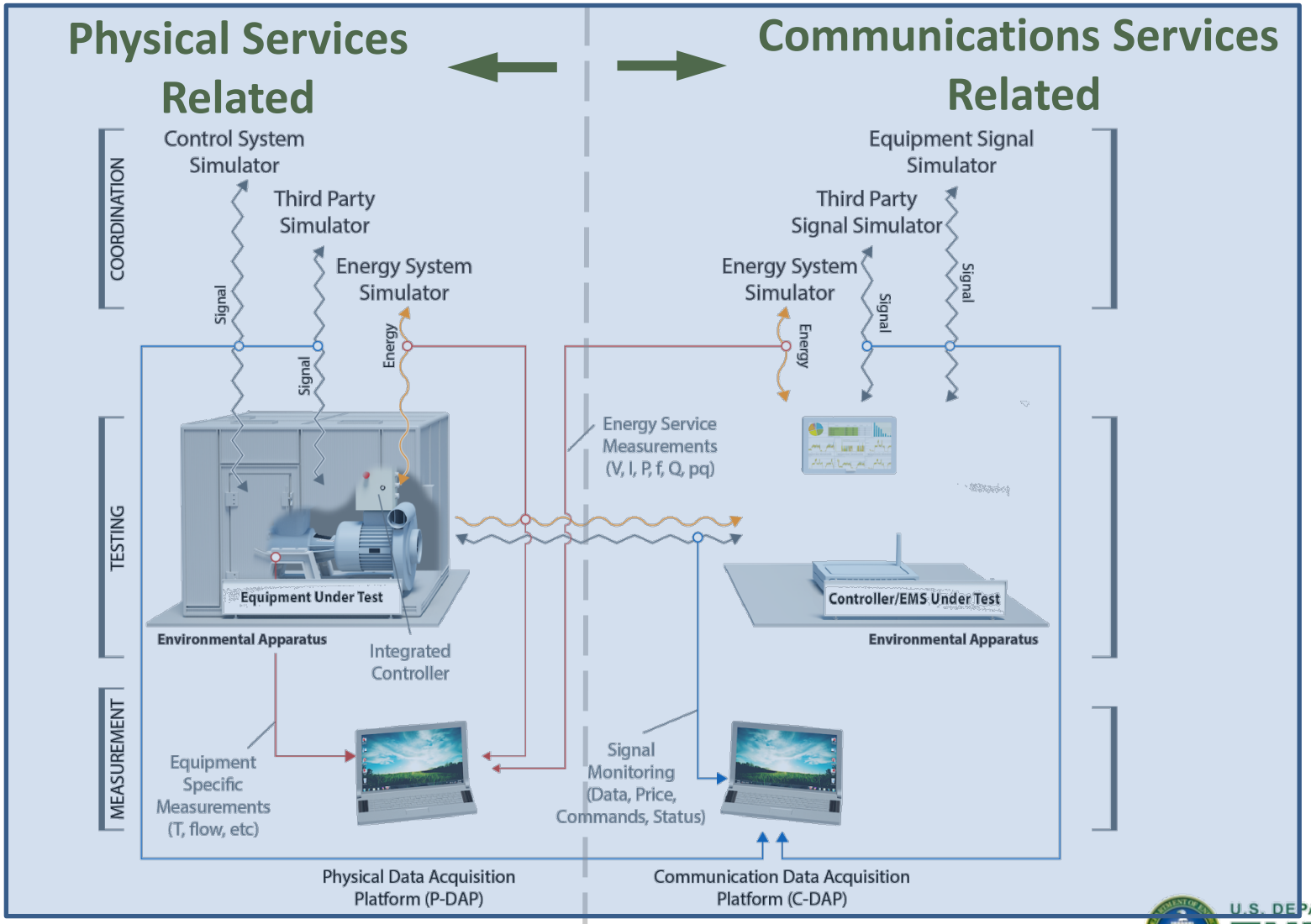
Measurement Questions

- Are there additional measurements that should be included?
- Is it preferable to separate characterization-only measurements from measurements that might also be present in rating laboratories (i.e. temperature)?

Characterization Experimental Setup



Advanced Characterization



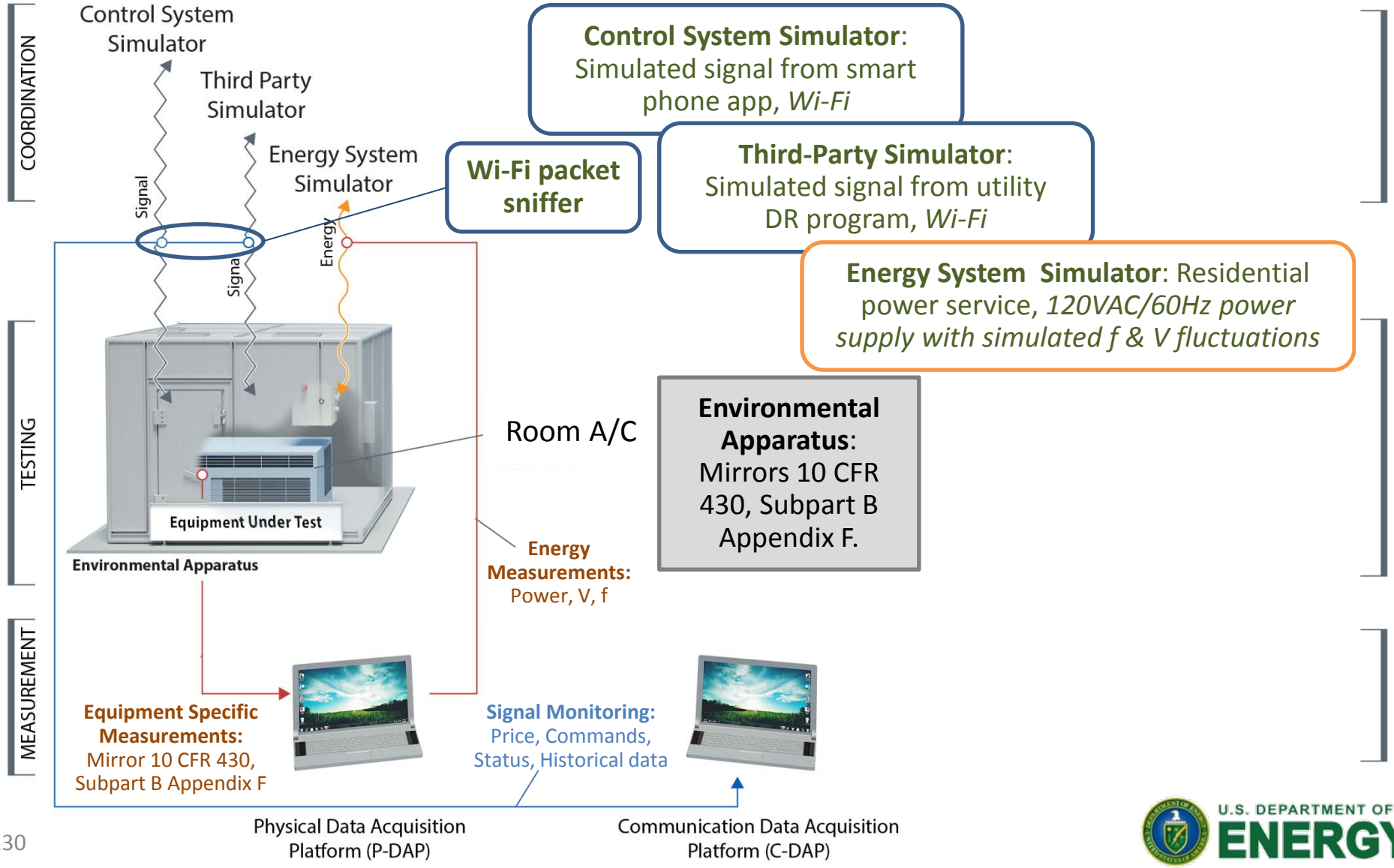
Questions

- Is Test-Coordinate-Measure the correct approach?
- Is additional clarification needed to define “testing” in the context of characterization?
- Are there testing components that facilitate characterization that are generally not present in rating laboratory test facilities that should be included here?
- Are there additional coordination mechanisms that should be included?
- Are there additional measurements that should be included?
- Is it preferable to separate characterization-only measurements from measurements that might also be present in rating laboratories (i.e. temperature)?

Illustrative Example: Room A/C

- Scenario: ACME Equipment, Inc., a RAC manufacturer, has hired Connected Certification Labs (CCL – a third-party certification laboratory) to characterize its connected RAC
- Test Configuration: CCL installs the RAC in the Environmental Apparatus, which is a calorimeter previously configured based on ASHRAE Standard 16 – Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners specifications
- Characterization Sequence:
  - Establish baseline performance using existing methods/equipment
  - **Electrical response** of the RAC to variations in voltage and frequency of electric power are characterized
  - **Load curtailment response** characterize ability to respond to third party signals for load curtailment
  - **Additional possible tests** include:
    - Time-of-use electricity price response (if capability is present)
    - Maximum acceptable temperature deviation from setpoint
    - Mode time limits (perhaps the load curtailment mode can only be used for 5 hours in a given day)

Illustrative Example: Room A/C



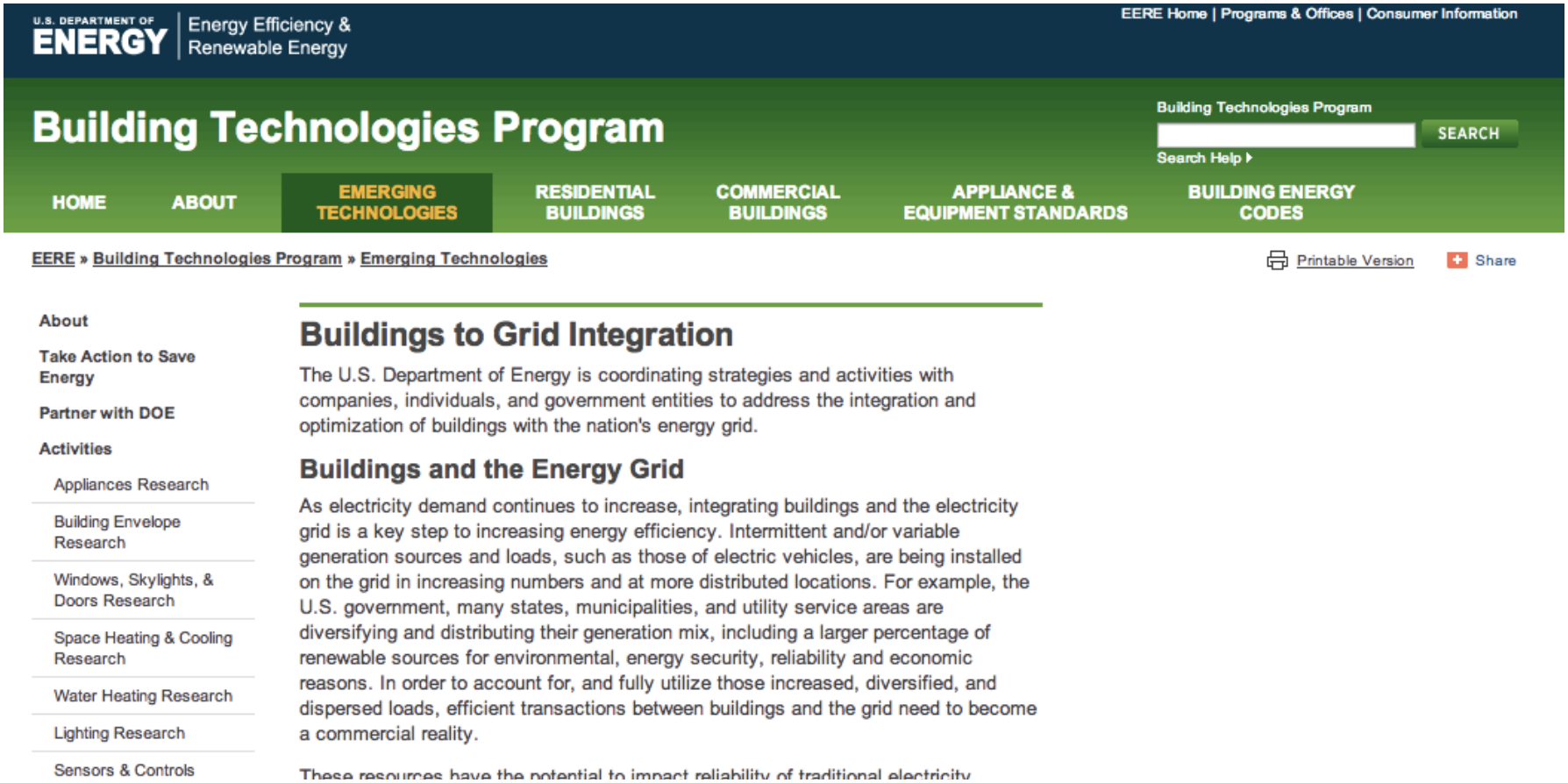
Next Steps

To be filled out after Day 1

EERE BTO's BTG Website

EERE >>> Building Technologies Program >>> Emerging Technologies

http://www1.eere.energy.gov/buildings/technologies/buildings_grid_integration.html



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